Emirates International University
Faculty of Medicine and Health Sciences

MEDICAL MICROBIOLOGY

2nd level / Pharm-D

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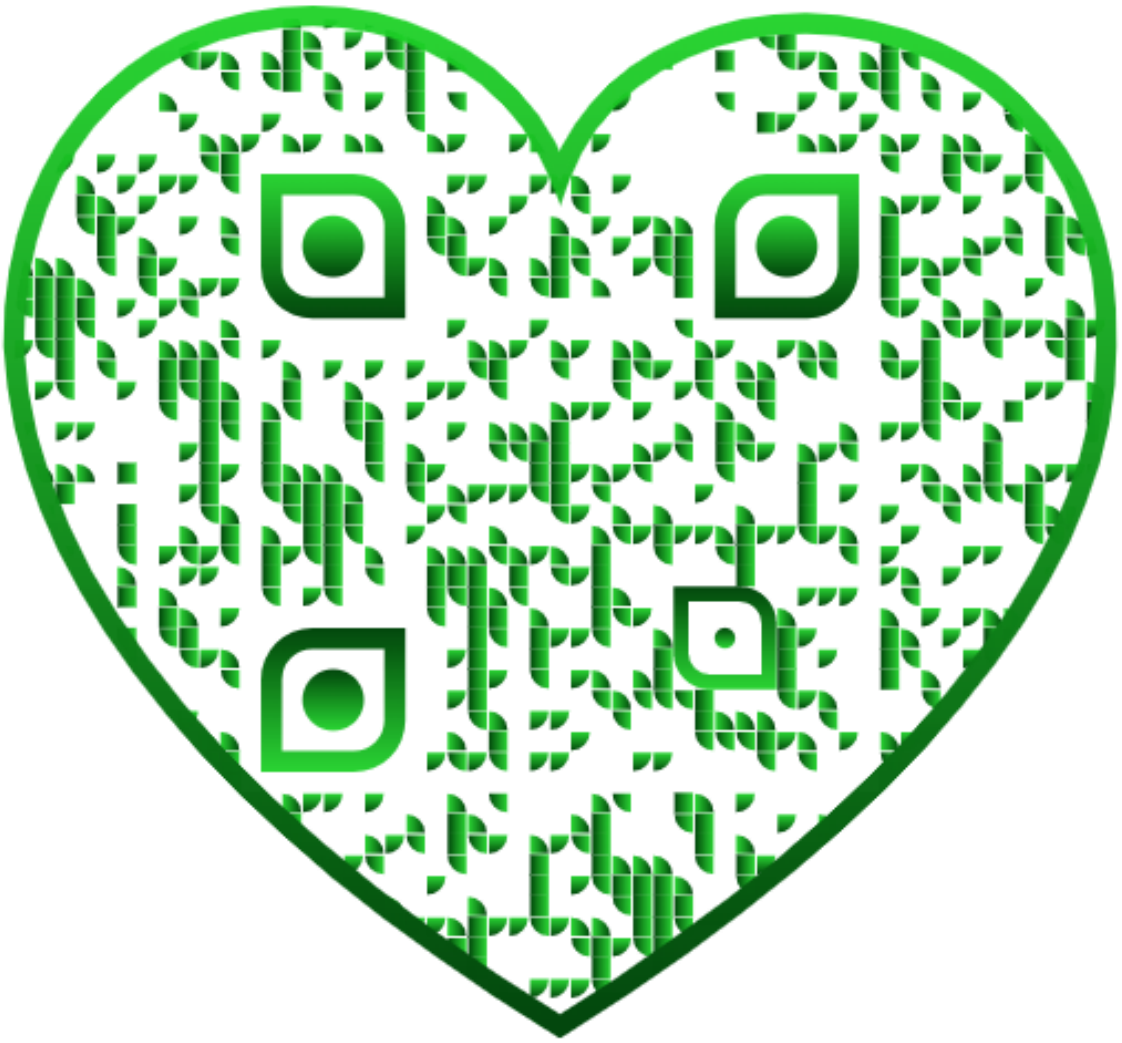
M.Sc. , M.D



1- Bacterial Morphology

Bacterial Morphology

- **According to microscopic examination:**

1) **Cocci** (Spherical),
2) **Bacillus** (Rod shaped),
3) **Spirillum** (Spirals),
4) Polymorph

Bacterial Morphology

1- Spherical (Cocci- coccus)

1- Aggregations- clusters (Grape like)

- Irregular clusters of cocci

e.g. *Staphylococci*

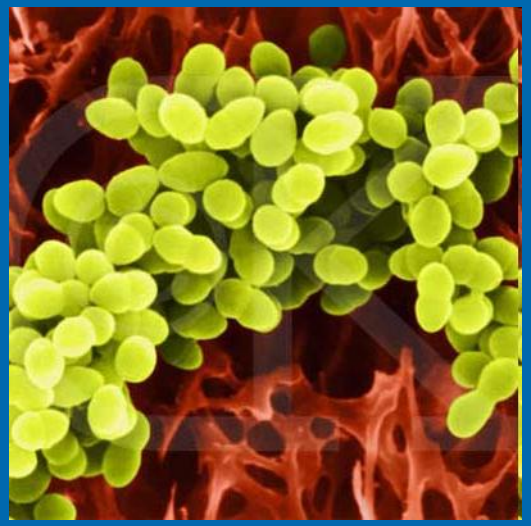
2- Diplococci

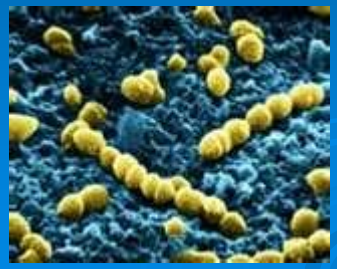
- Pairs of cocci

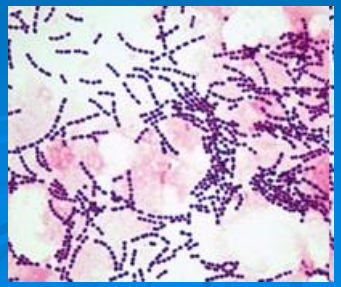
e,.g. *Streptococci pneumonia*

3- Chains of cocci

Strept.pyogens



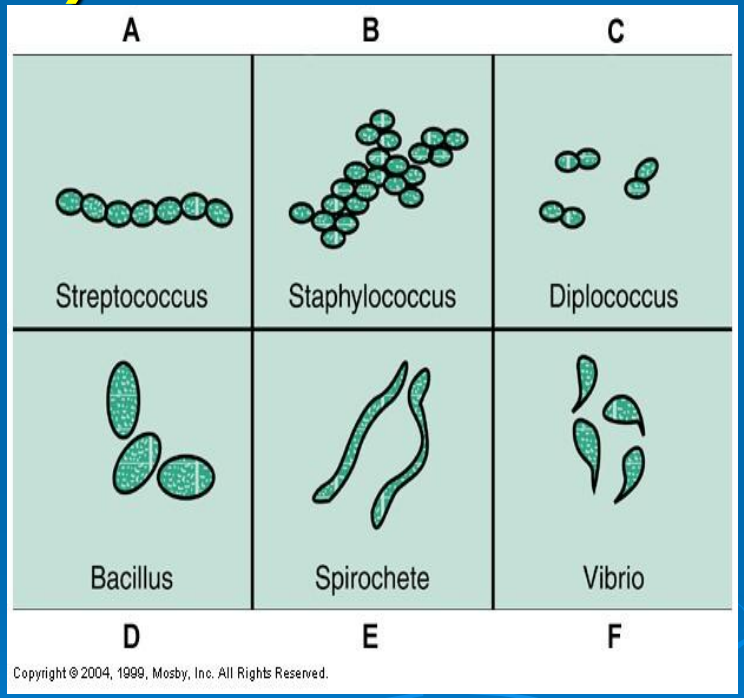




Bacterial Morphology

2- Rod like (Bacilli- bacillus)

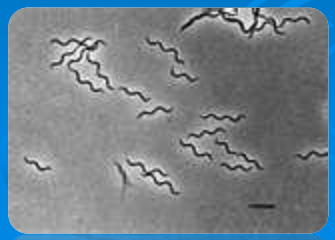
- Rod like
- *Diplo bacilli*
  - Pairs of bacilli
- *Strepto bacilli*
  - Chains of bacilli



3- Spirochetes

- Spiral

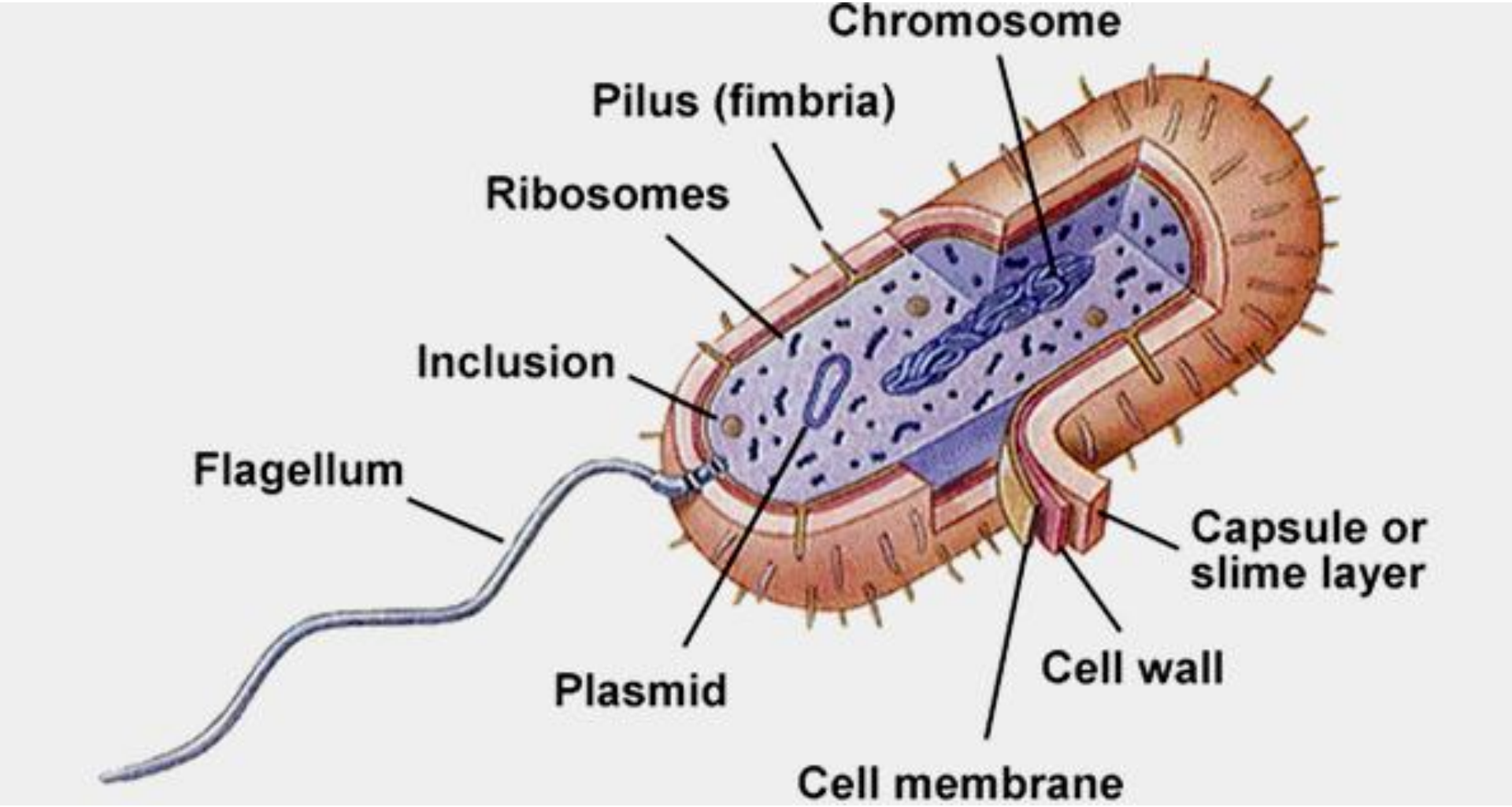
e.g. *T.pallidium*



4- Polymorph: (*V.cholera*)

2- Bacterial Cell Structure

Bacterial Cell Structures



Bacterial Structures

- **Basic structures:**
  - Nucleoid, Cytoplasm, Cell membrane , Cell wall.
- **Special structures:**
  - Flagella , Pili, Endospore, Capsule

Basic Structures

1-Nucleoid

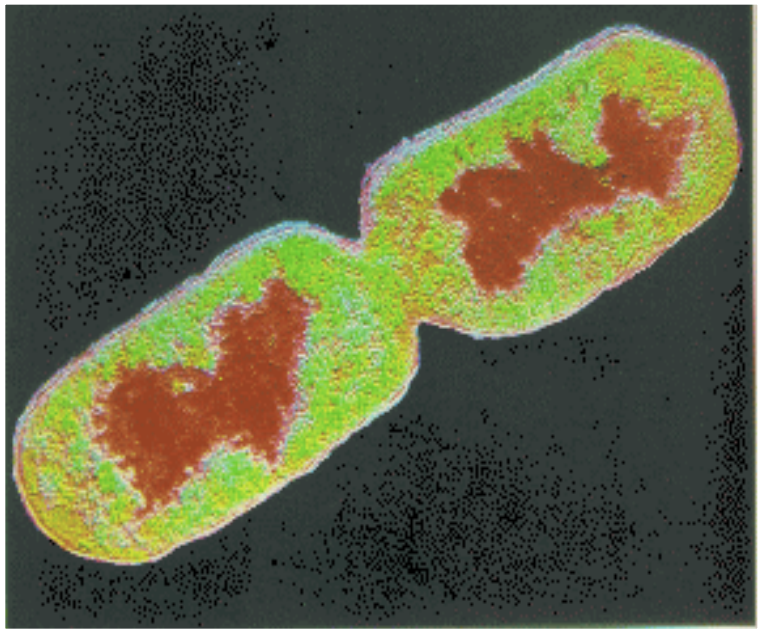
2-Cytoplam

3-Cell membrane

4-Cell wall

1-Nucleoid

- Circular, double-stranded DNA.
- It is not compartmentalized by membrane.



E. coli: 4,639 kb, contains 3,000 ~ 5,000 genes

2-Cytoplasm

It consists of 80% Water {20% Salts-Proteins).

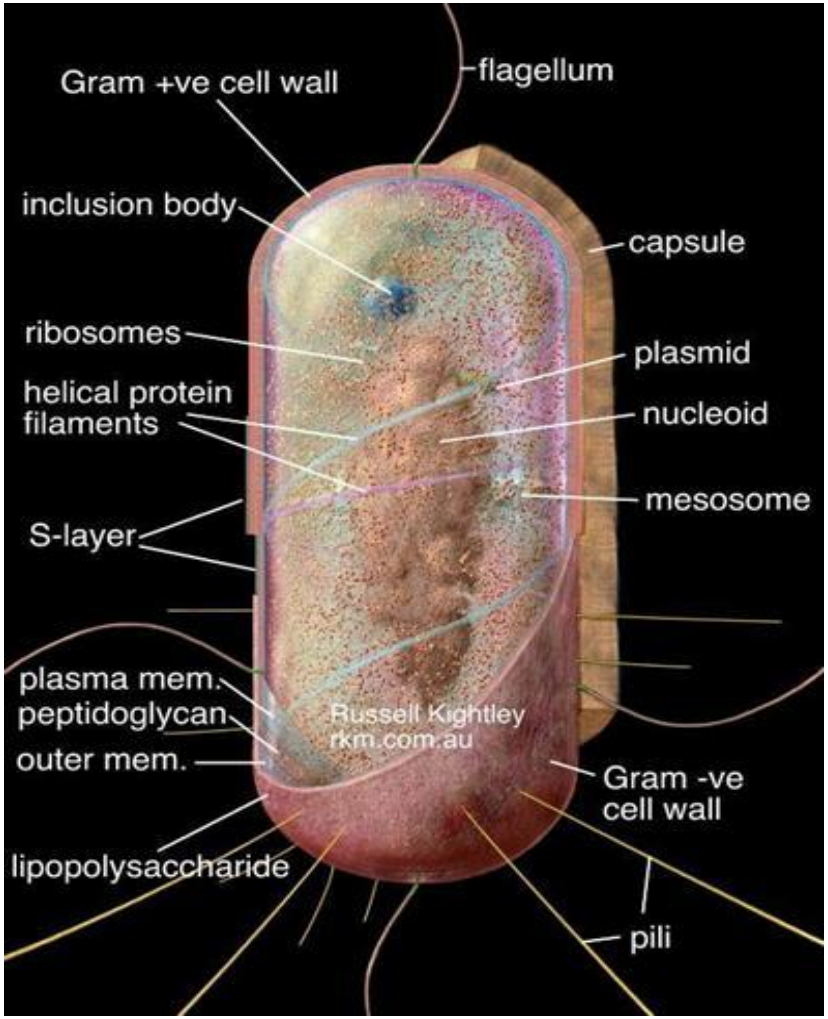
It includes:

A. Ribosome

B. Plasmid

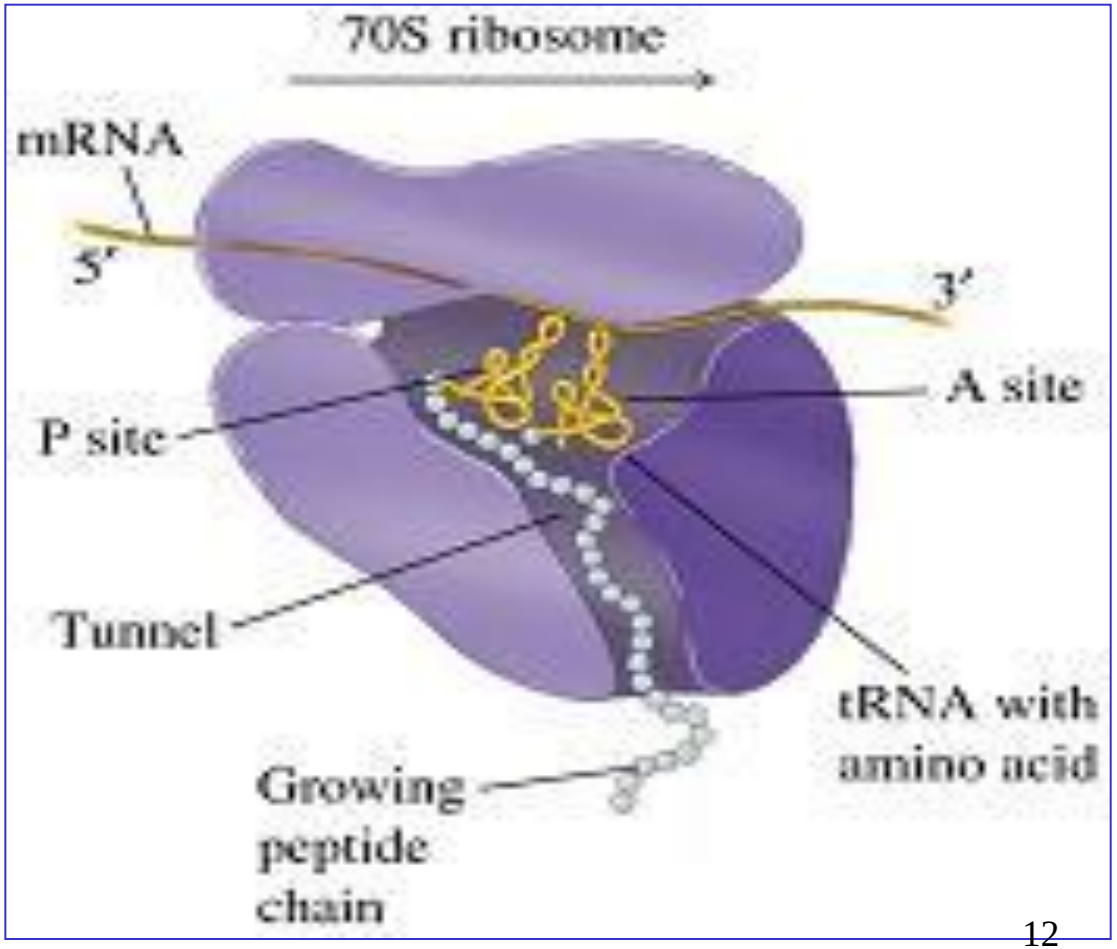
C. Granules

D. Mesosome



A) Ribosome

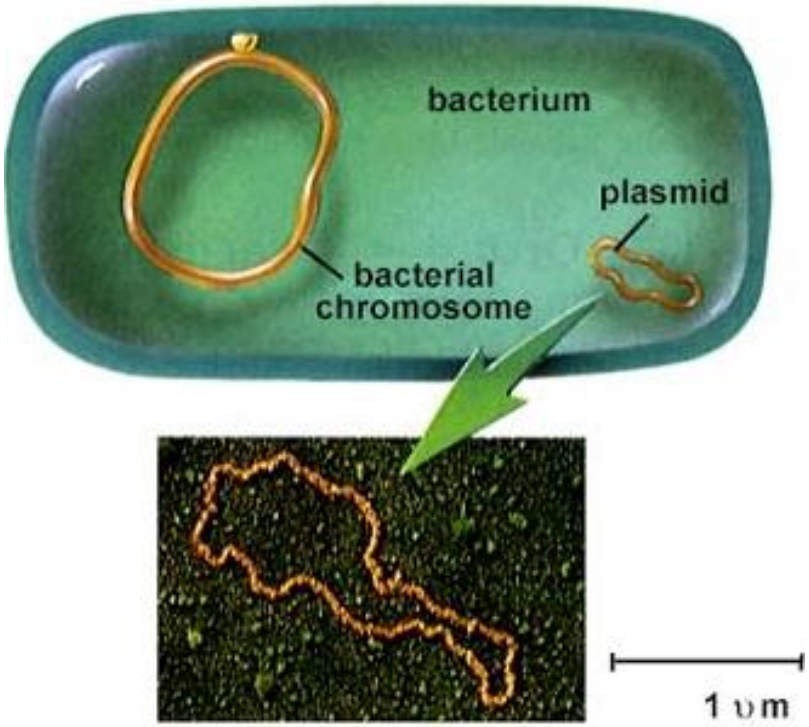
- 70S, Two subunits:
  - **50S**
  - **30S**
  - Smaller than eukaryotic ribosome



B) Bacterial **Plasmid**

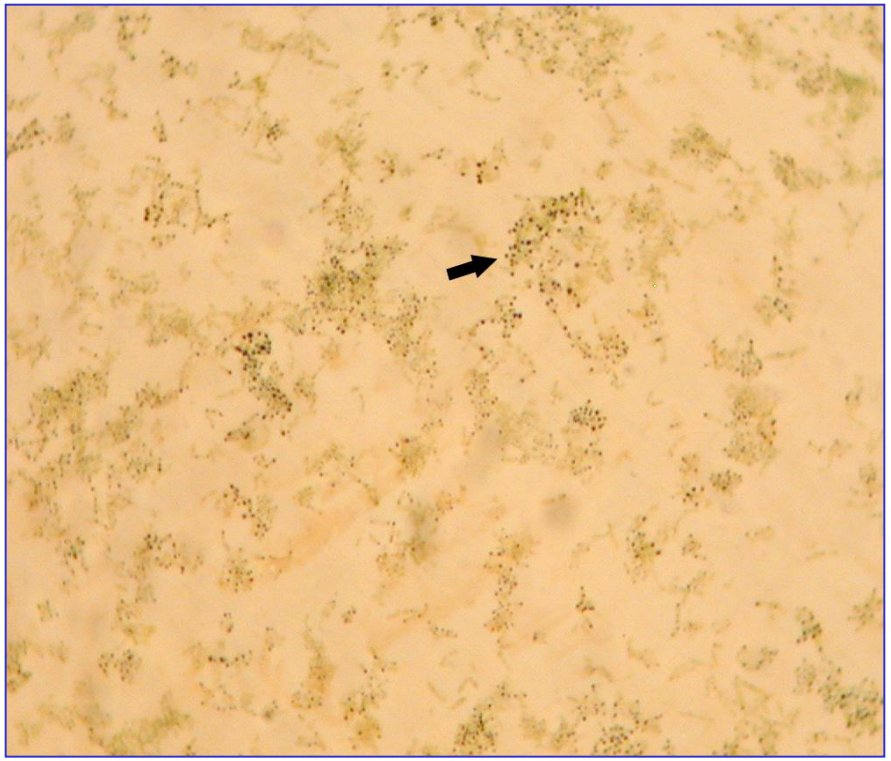
- Extra-chromosomal DNA.
- Coding pathogenesis and antibiotic resistance factors.

- Bacterial replication independently..



C) Cytoplasmic Granules

- Nutrients
- Metachromatic granule:
  - Basic
  - Differential value
    - *Corynebacterium diphthriae*

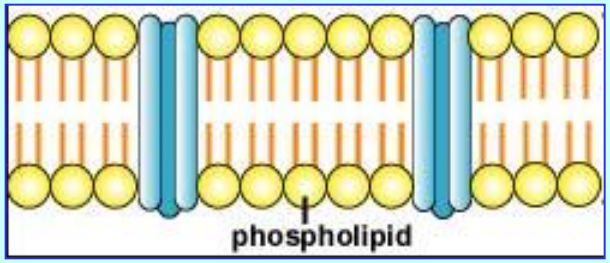


D) Mesosome

- Mitochondria-like organelle in bacteria.
  - Energy synthesis.
- Folded by cell membrane.
- **Gram positive cells**.
- Work as spindle apparatus.

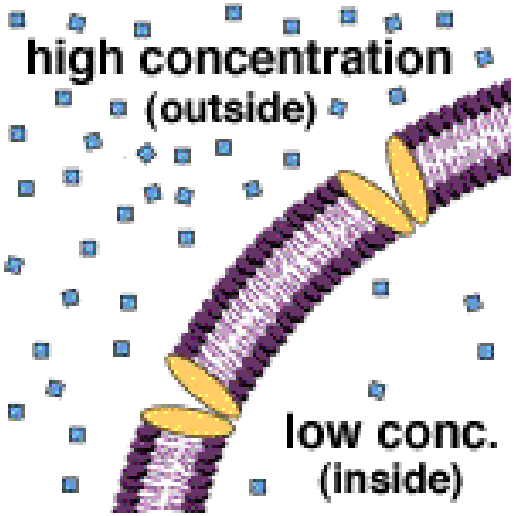
3) Cell Membrane

- Semi-permeable.
- Functions:
  - Permeability and transport.
  - Excretion hydrolytic exo-enzymes and pathogenic proteins.
  - Energy production.
  - Biosynthesis functions.

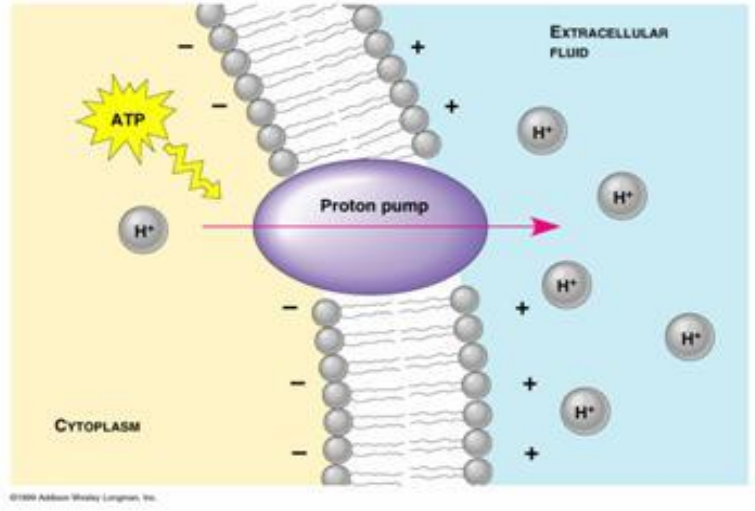


Transport Across the **Cell Membrane**

- **Basic rule**: things spontaneously move from high concentration to low concentration (downhill). This process is called **diffusion**.
  - Getting many molecules into the cell is simply a matter of opening up a protein channel of the proper size and shape. The molecules then move into the cell by diffusing down the concentration gradient. **Passive transport**, or **facilitated diffusion.**



- To get things to move from low to high (uphill), you need to add energy: the molecules must be pumped into the cell. Pumps are driven by ATP energy. **Active transport**.



4) Cell Wall

- Functions:

Maintain the shape of bacterium.

Rigid, protecting cell from osmotic lysis.

Exchange nutrients and chemicals.

Antigenicity.

Relate to its pathogenesis.

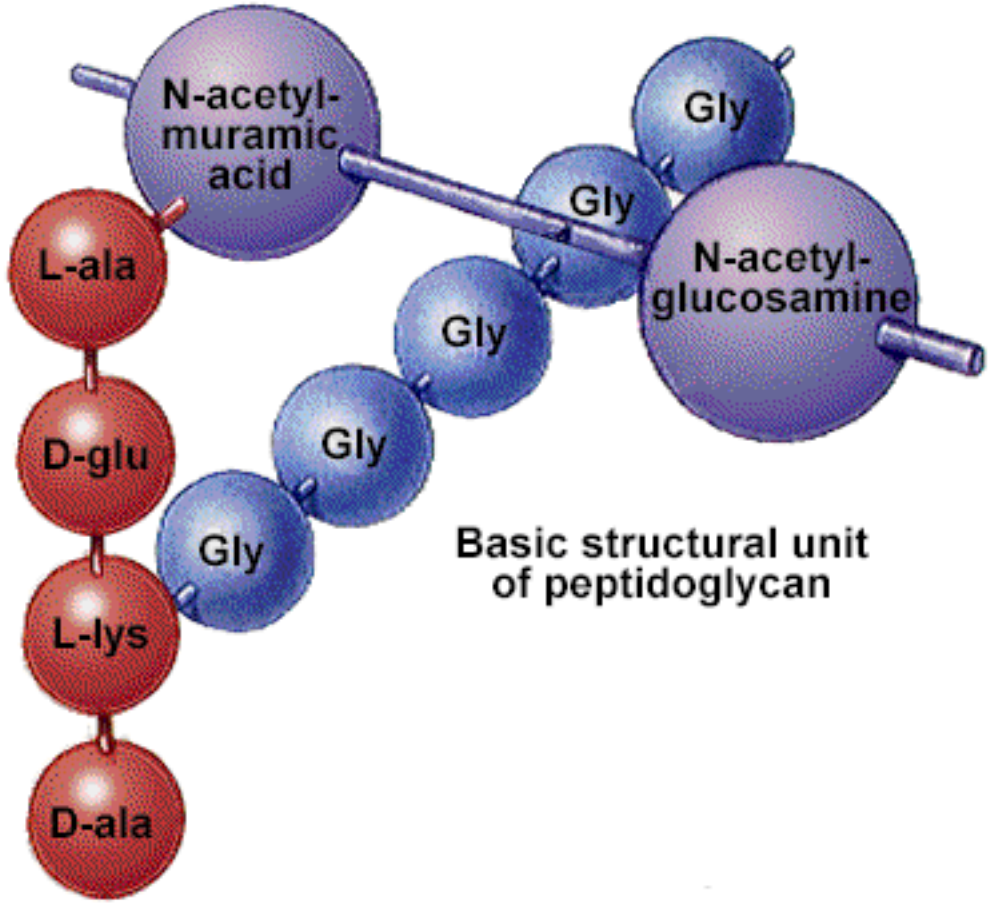
4) Cell Wall

- **Structure:**

Peptidoglycan

Similarities and differences between the Gram + / - cell walls.

Peptidoglycan



4) Cell Wall

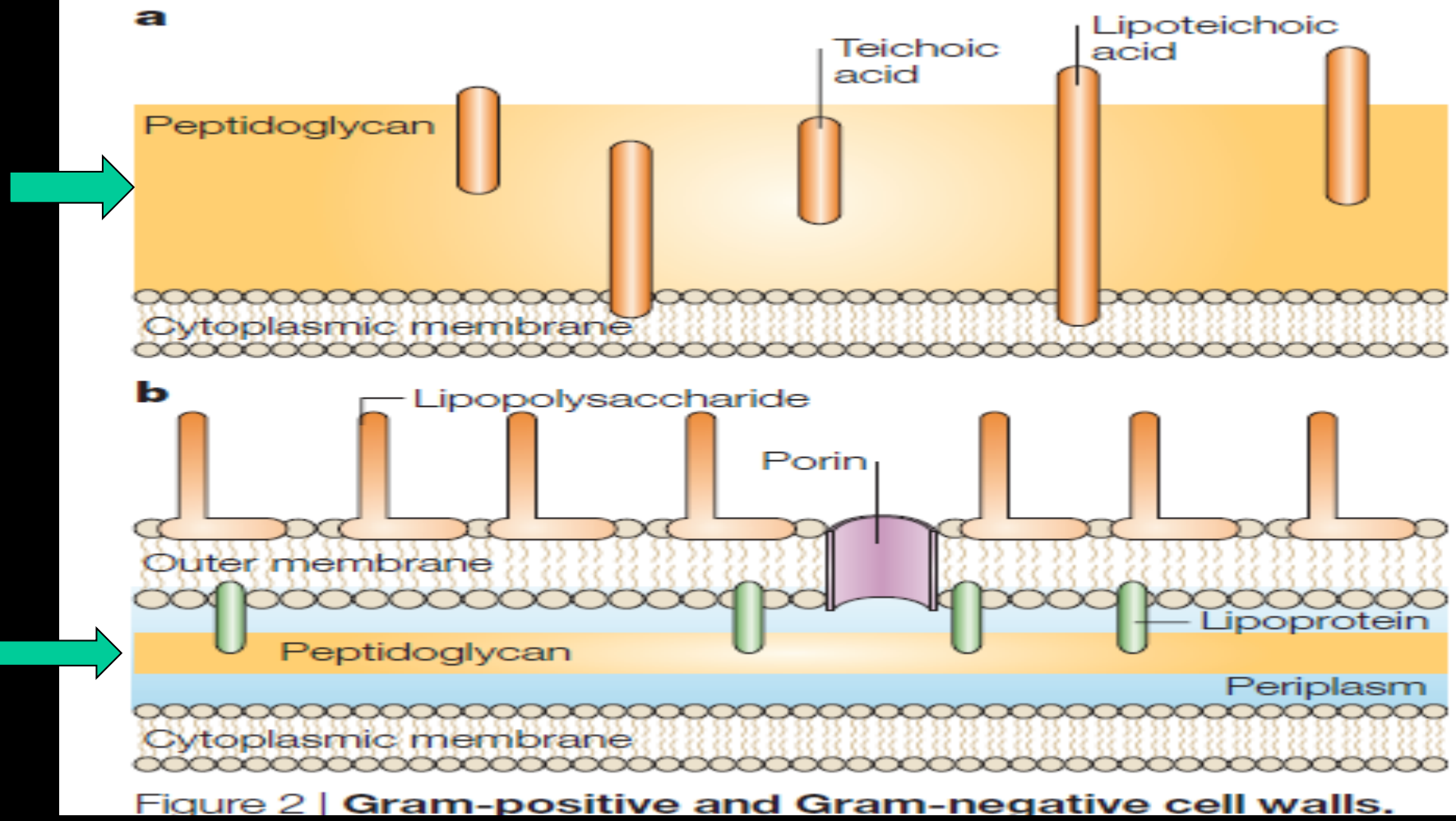


Figure 2 | **Gram-positive and Gram-negative cell walls.**

Special Structures

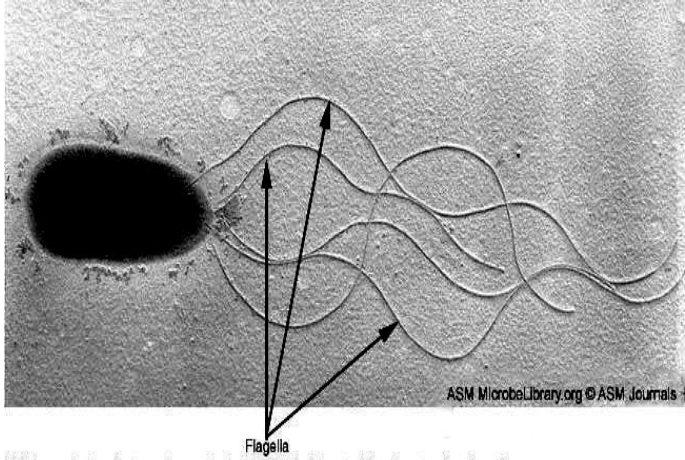
1-Flagellum

2-Pili

3-Capsule

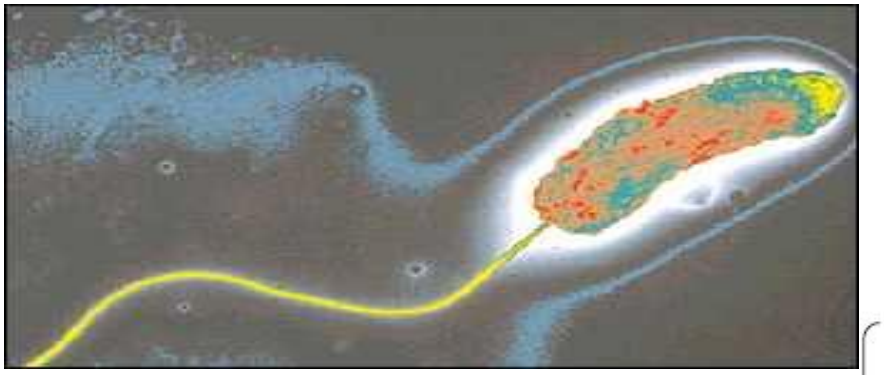
4-Endospore

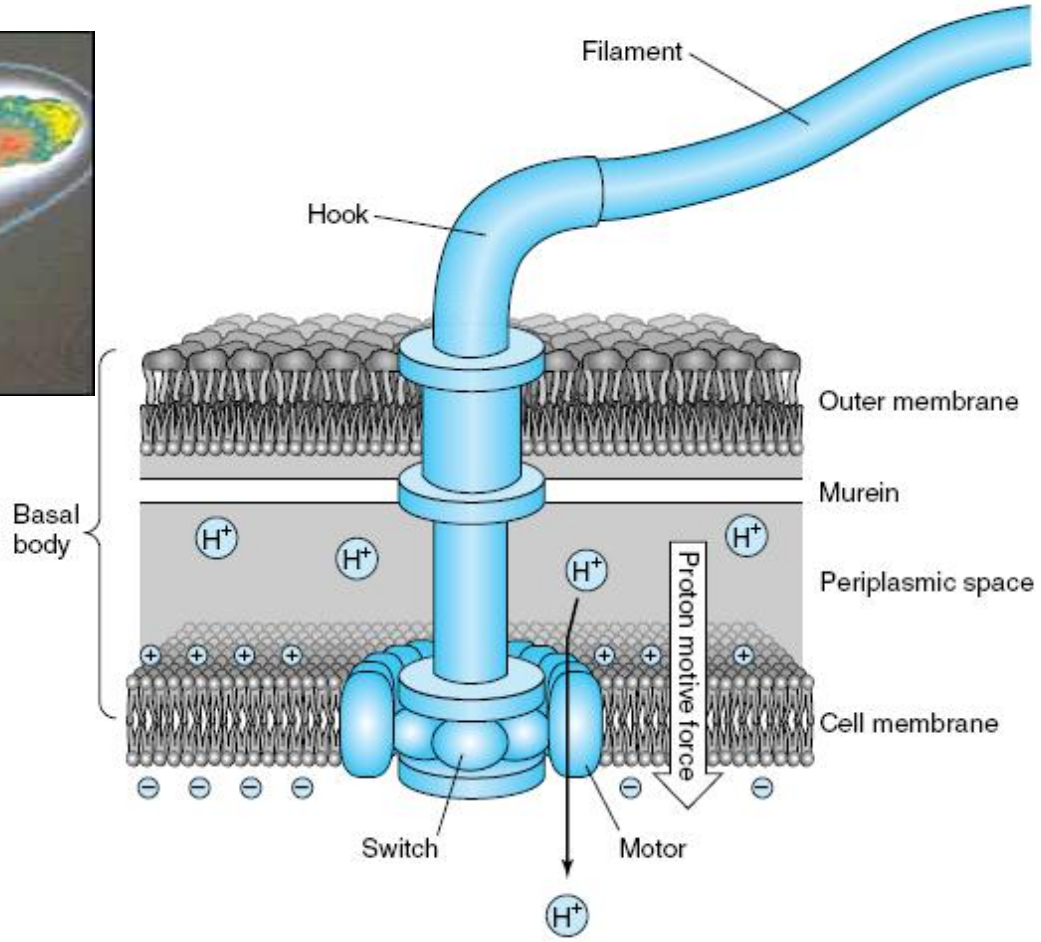
1- Flagellum



This transmission electron micrograph shows six polarly located flagella extending from the bacterium, *Pseudomonas putida*. In this case, the cell is 2 µm in length, and each flagellum is ~5 to 7 µm long.

- Some bacteria are motile.
- Locomotors organelles- flagella.
- Taste environment.
- Respond to food/poison
  - Chemotaxis.



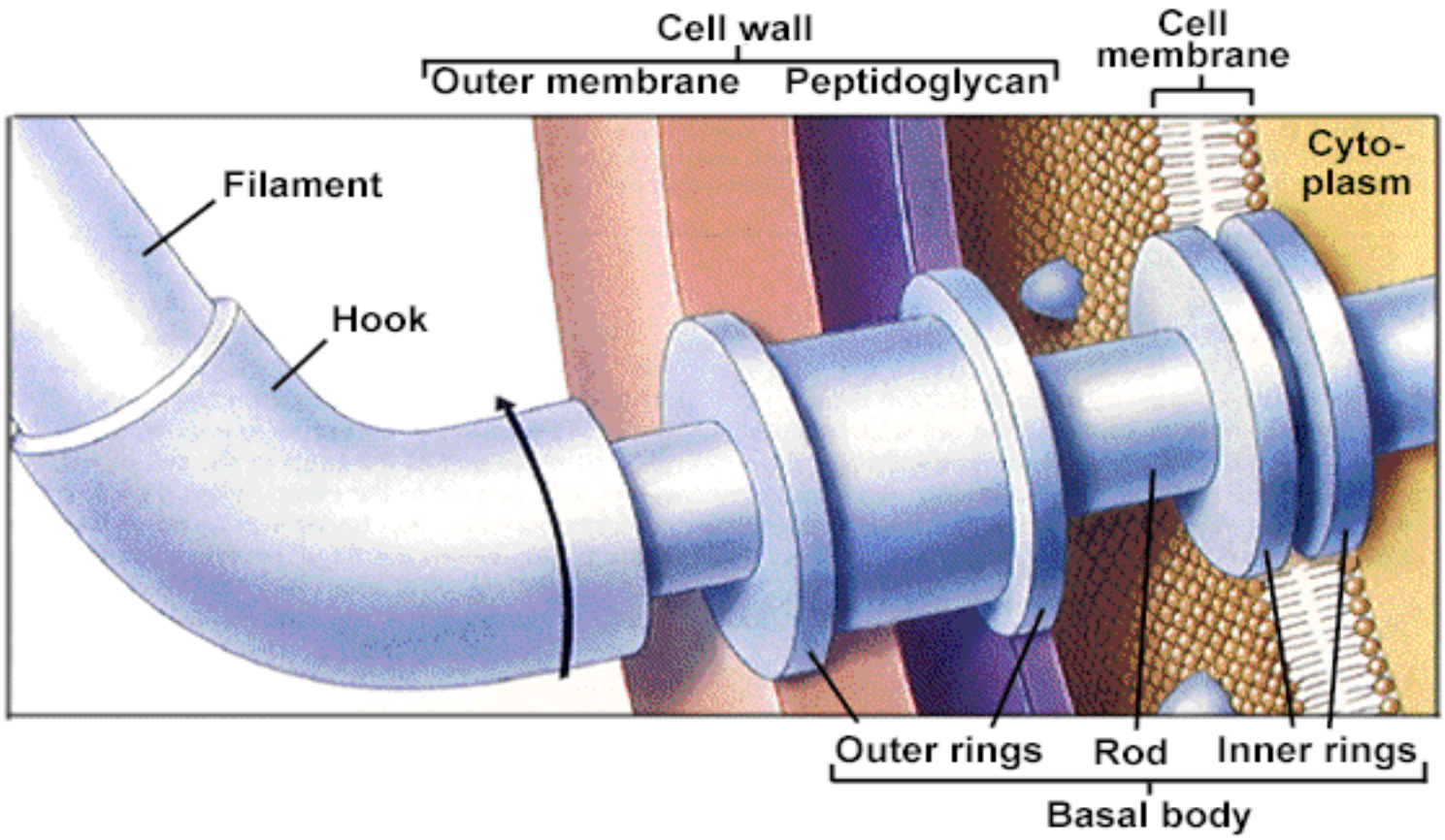


➢ Structure:

- Embedded in cell membrane
- Project as strand
- Flagellin (protein) subunits
- Move cell by propeller like action

1- Flagellum

- **Structure:**



➢ Flagellum types:

Monotrichous	Lophotrichous	Peritrichous
Vibrio cholerae	*Spirilla*	*E. coli*

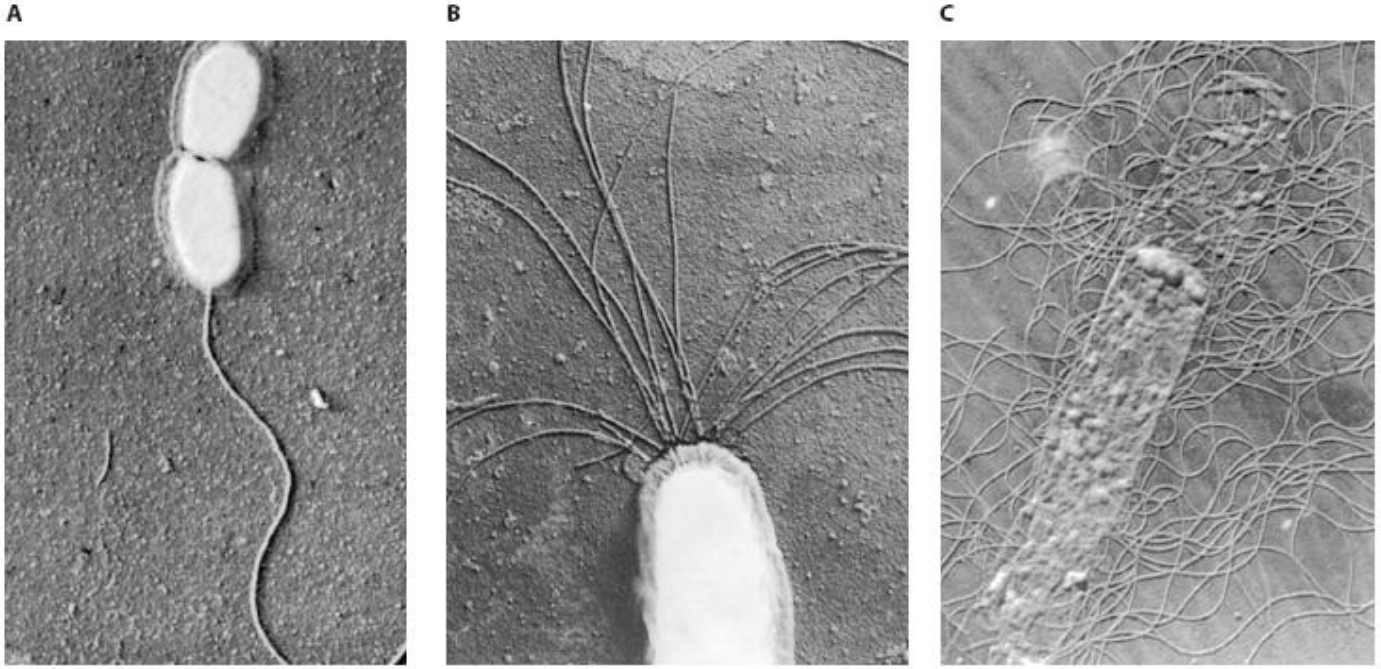


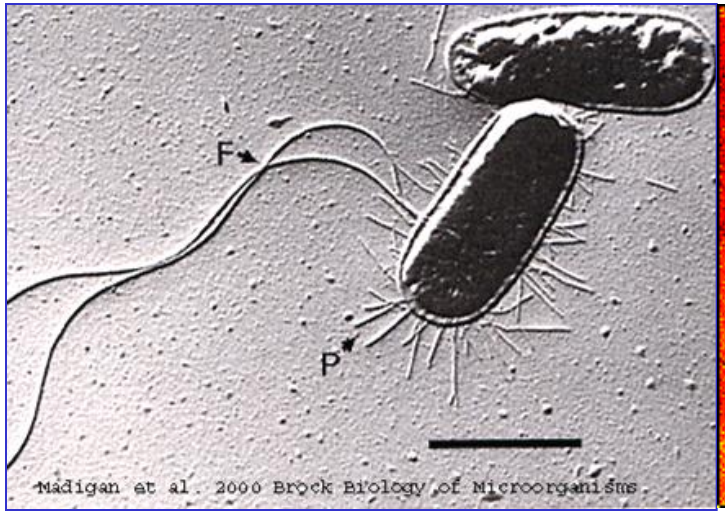
Figure 2–26. Bacterial flagellation. **A:** *Vibrio metchnikovii,* a monotrichous bacterium (7500 ×). (Courtesy of van Iterson W: Biochim Biophys Acta 1947;1:527.) **B:** Electron micrograph of *Spirillum serpens,* showing lophotrichous flagellation (9000 ×). (Courtesy of van Iterson W: Biochim Biophys Acta 1947;1:527.) **C:** Electron micrograph of *Proteus vulgaris,* showing peritrichous flagellation (9000 ×). Note basal granules. (Courtesy of Houwink A, van Iterson W: Biochim Biophys Acta 1950;5:10.)

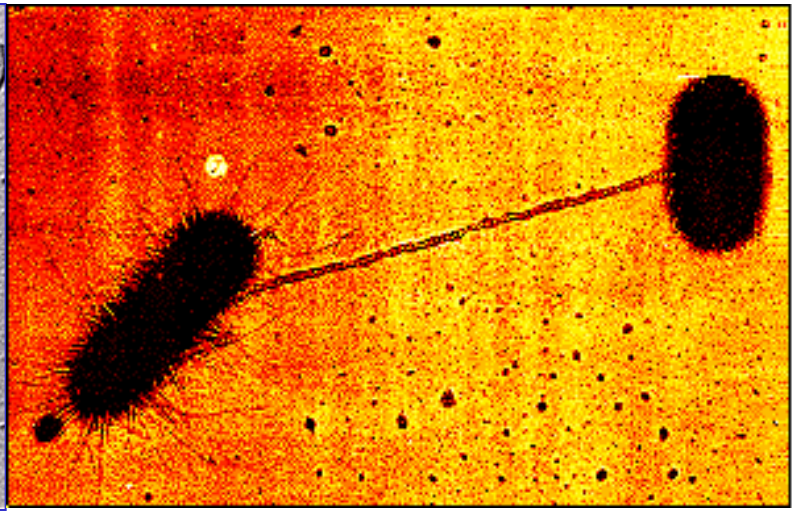
Functions of Flagellum

- Protein, antigenic (H.Ag).
- Locomotory strucutre.
- Adherence factor.
- Differentiation.

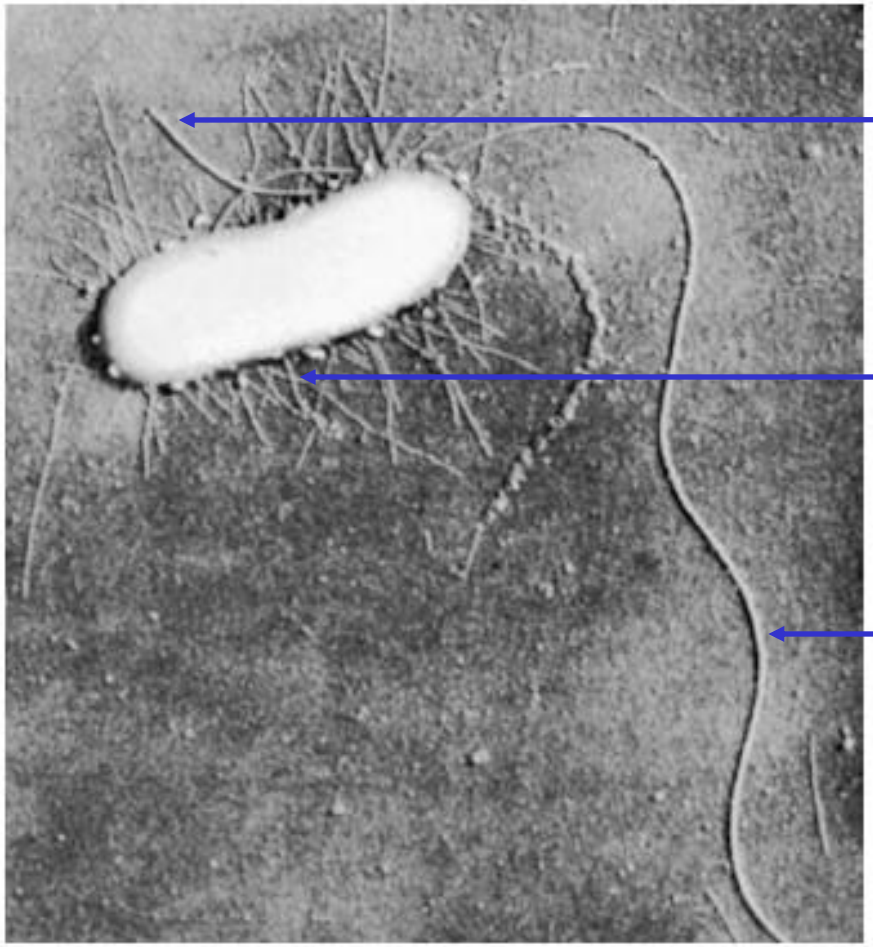
2) Pili (fimbriae, Pilus)

- Hair-like projections of the cell.
- Sexual conjugation.
- Adhesion to host epithelium.





➢ Pilus types:



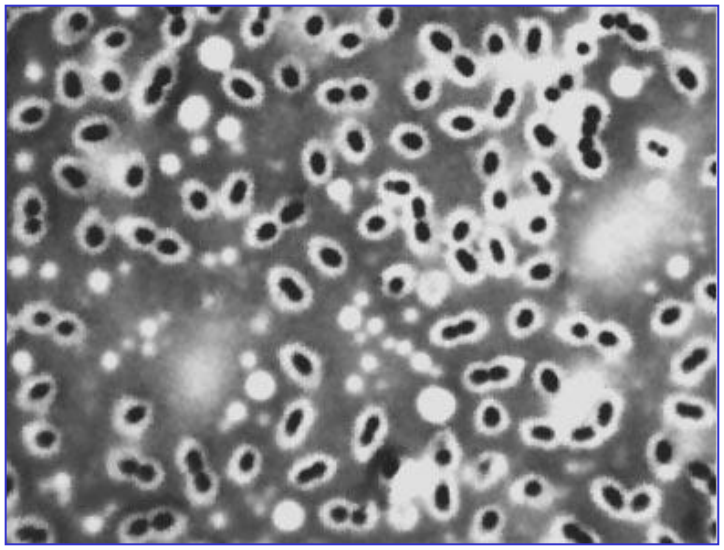
1- Sex pilus

2- Ordinary pilus

Flagellum

Figure 2–30. Surface appendages of bacteria. Electron micrograph of a cell of *E coli* possessing three types of appendages: ordinary pili (short, straight bristles), a sex pilus (longer, flexible, with phage particles attached), and several flagella (longest, thickest). Diameters: ordinary pili: 7 nm; sex pili: 8.5 nm; flagella: 25 nm. (Courtesy of J Carnahan and C Brinton.)

3) Capsules & Slime Layers



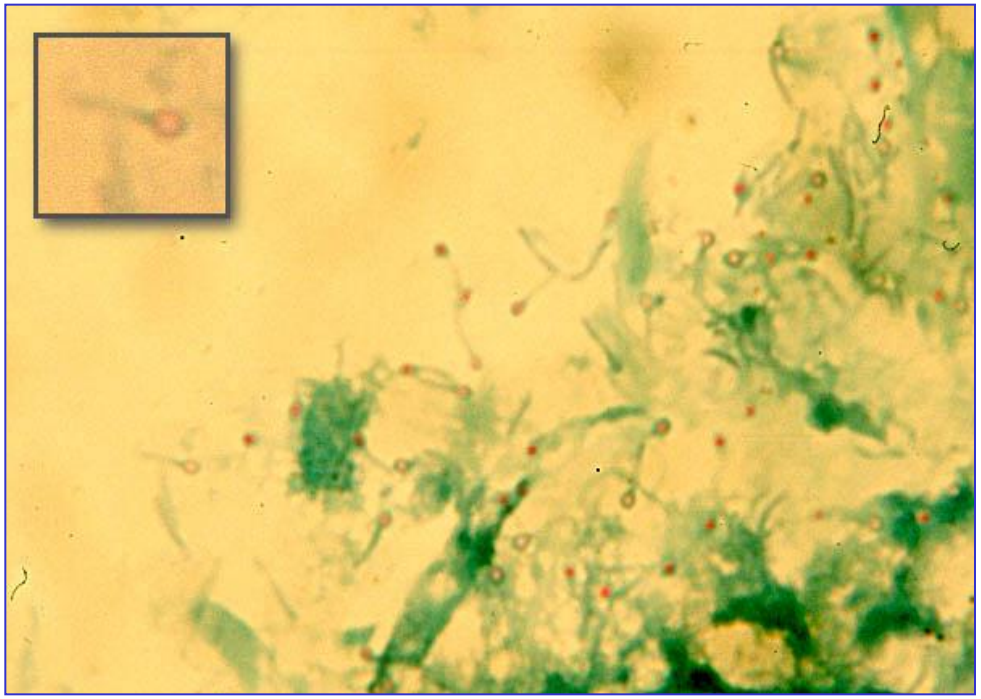
- Outside cell envelope.
  - well defined: Capsule.
  - not defined: slime layer or Glycocalyx.
- Usually polysaccharide.
- Often lost on *in vitro* culture.
- Protective *in vivo.*

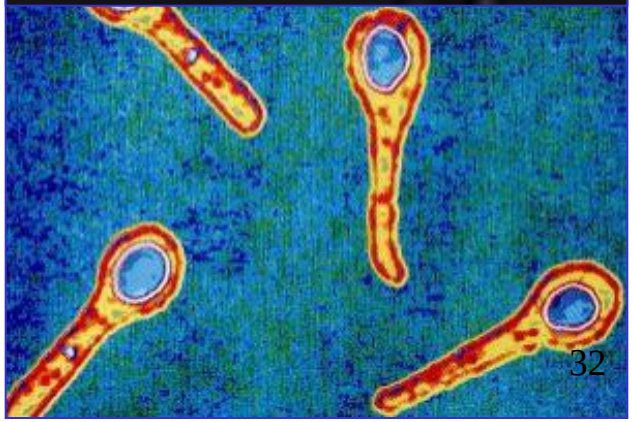
Special Stains

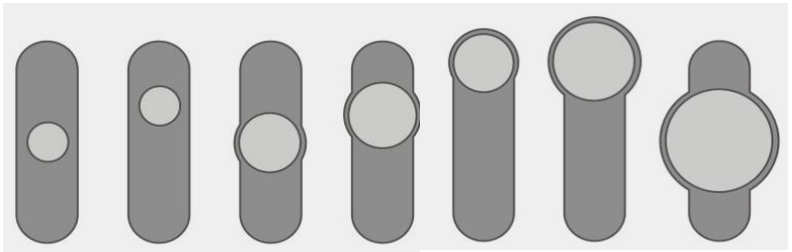
Capsule Stain

Klebsiella pneumoniae

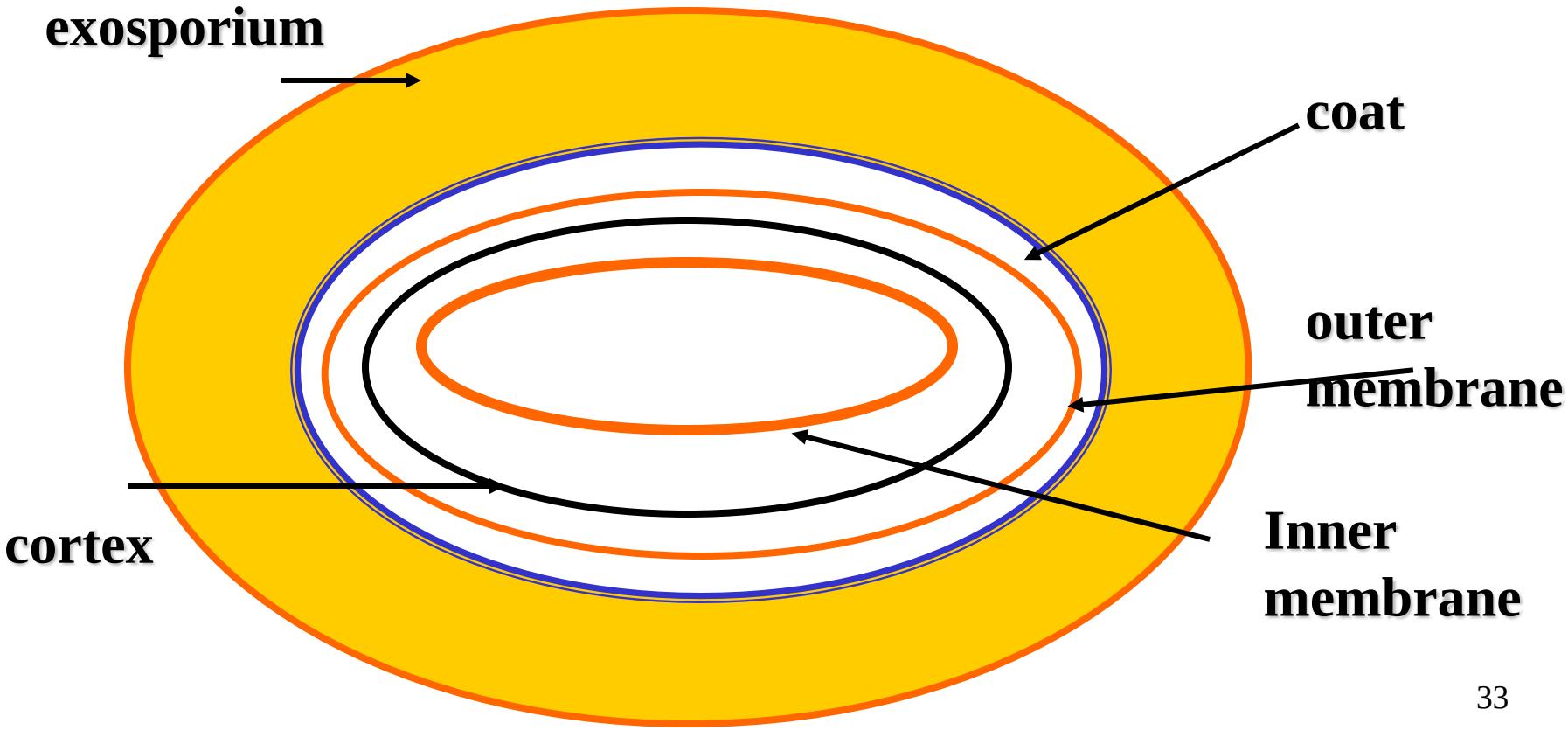
4) Endospores (Spores)







The endospore Structure



4) Endospores (Spores)

- Dormant cell.
- Produced when starved.
- Resistant to adverse conditions.
  - high temperatures.
  - organic solvents.
- Contain calcium dipicolinate.
- *Bacillus* and *Clostridium. (G+)*

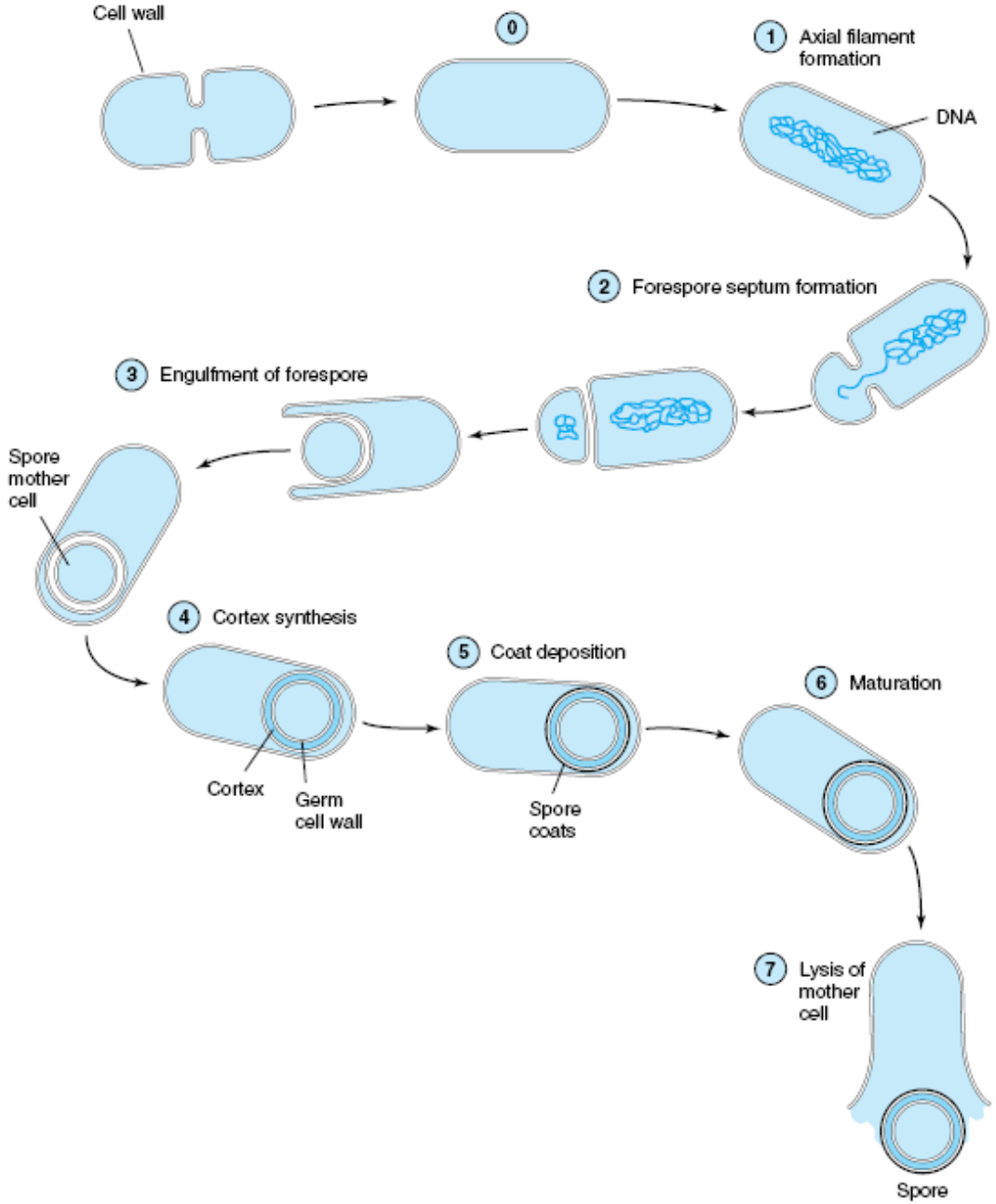
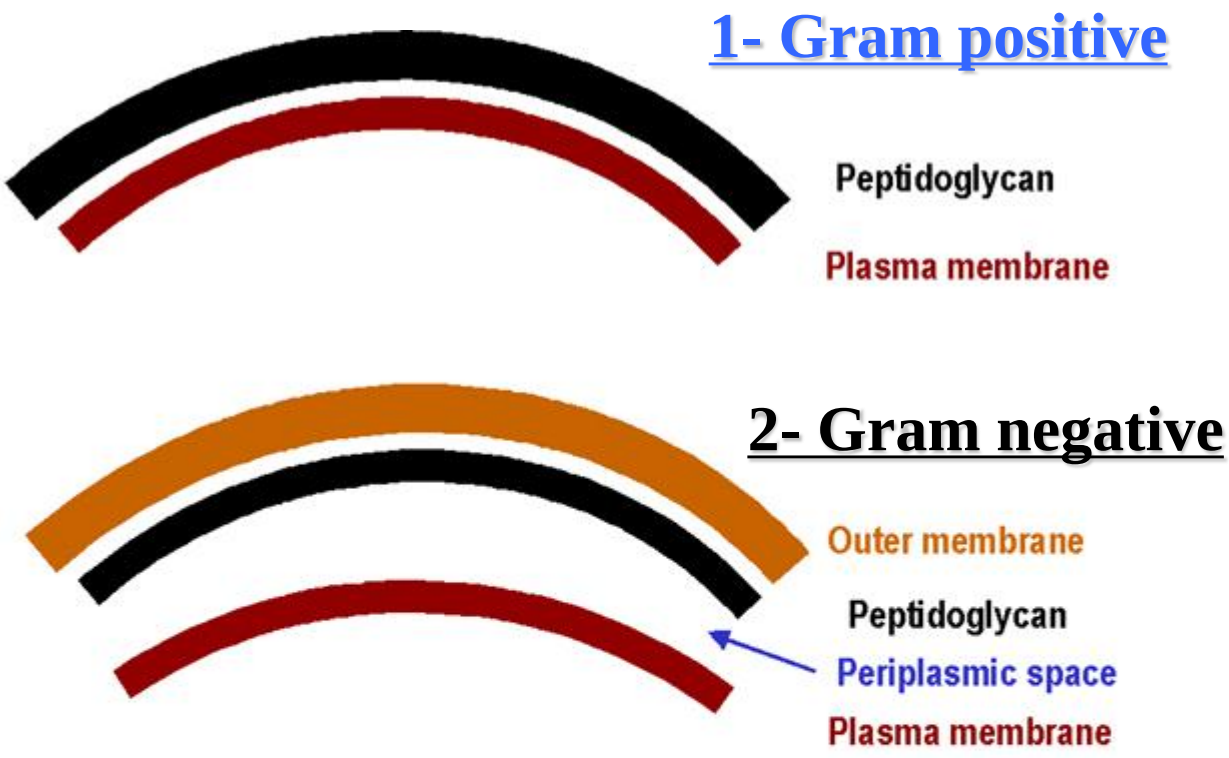


Figure 2–32. The stages of endospore formation. (Reproduced, with permission, from Merrick MJ: Streptomyces. In: *Developmental Biology of Procaryotes*. Parish JH [editor]. Univ California Press, 1979.)

Bacterial Cell Wall structure

Peptidoglycan

Similarities and differences between the Gram + / - cell walls



Comparison of G+ / G- cell walls

Bacterial Cell Wall structure

➢ Peptidoglycan:

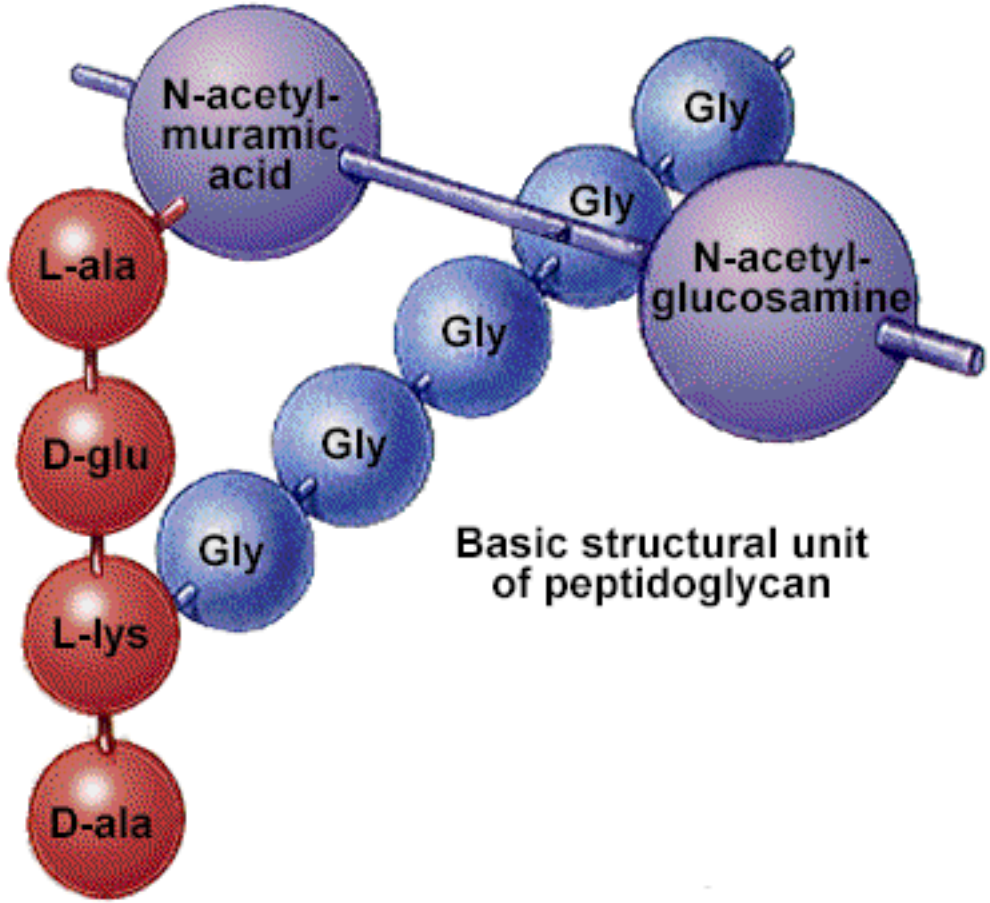
- Single macromolecule.
- Highly cross-linked.
- Surrounds cell.
- Provides rigidity.

➢ Peptidoglycan

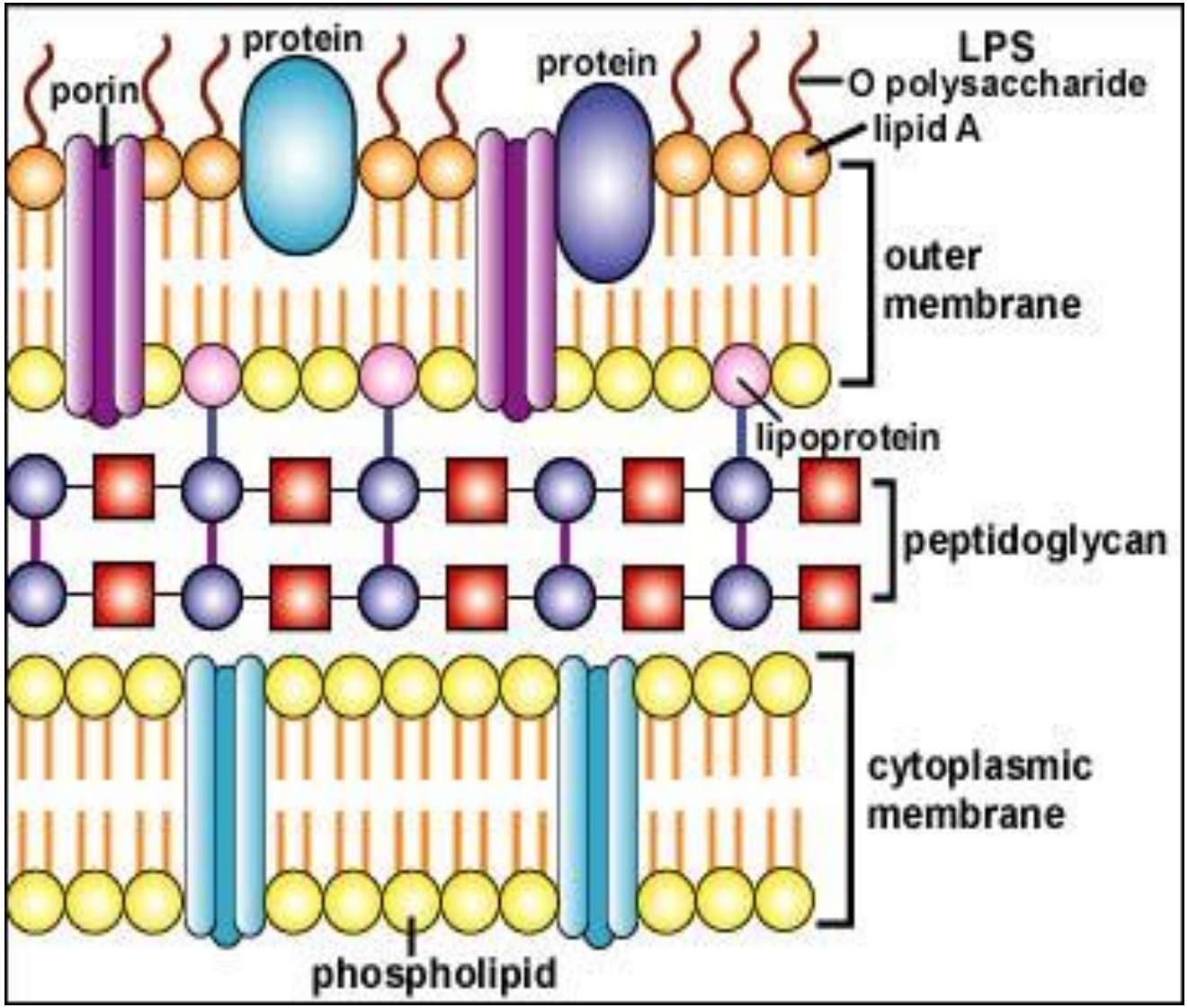
- **Glycan backbone:**
  - **Muramic acid.**
  - **Glucosamine.**

- **Peptide side chain**
- **Peptide cross-bridge**
  - **D- and L- amino acids**
  - **diaminopimelic acid**

Peptidoglycan



Gram Negative Cell Wall

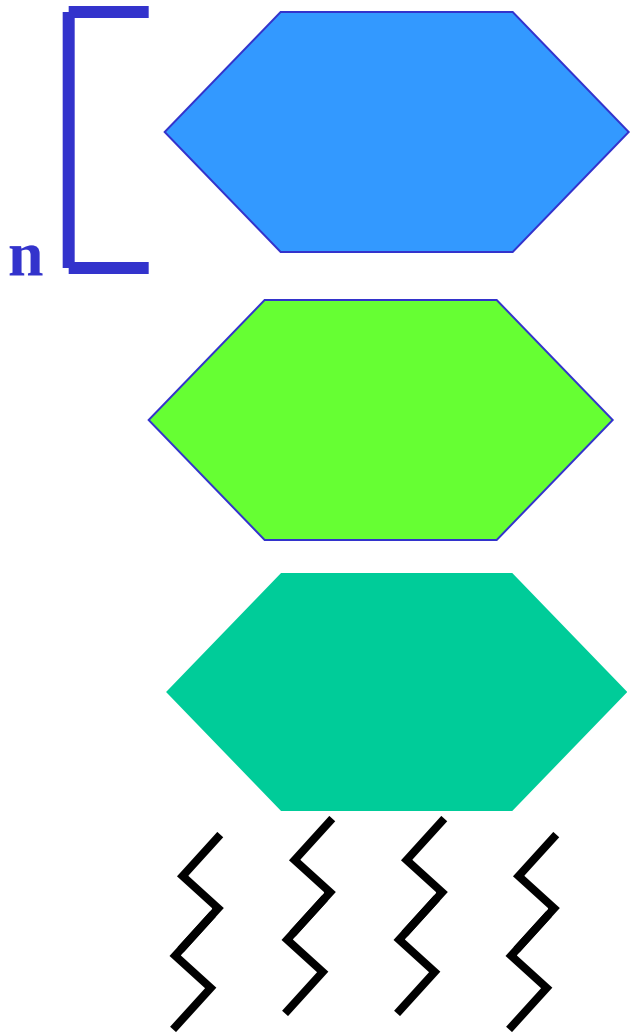


Gram Negative Cell Wall

Outer Membrane

- Lipopolysaccharide (LPS)
  - Endotoxin
- Phospholipids.
- Proteins.
  - porins

Lipopolysaccharide



O-antigen

- **Highly variable**

Core

- **Heptoses**
- **Ketodeoxyoctonic acid**

Lipid A

- **Glucosamine disaccharide**
- **Beta hydroxy fatty acids**

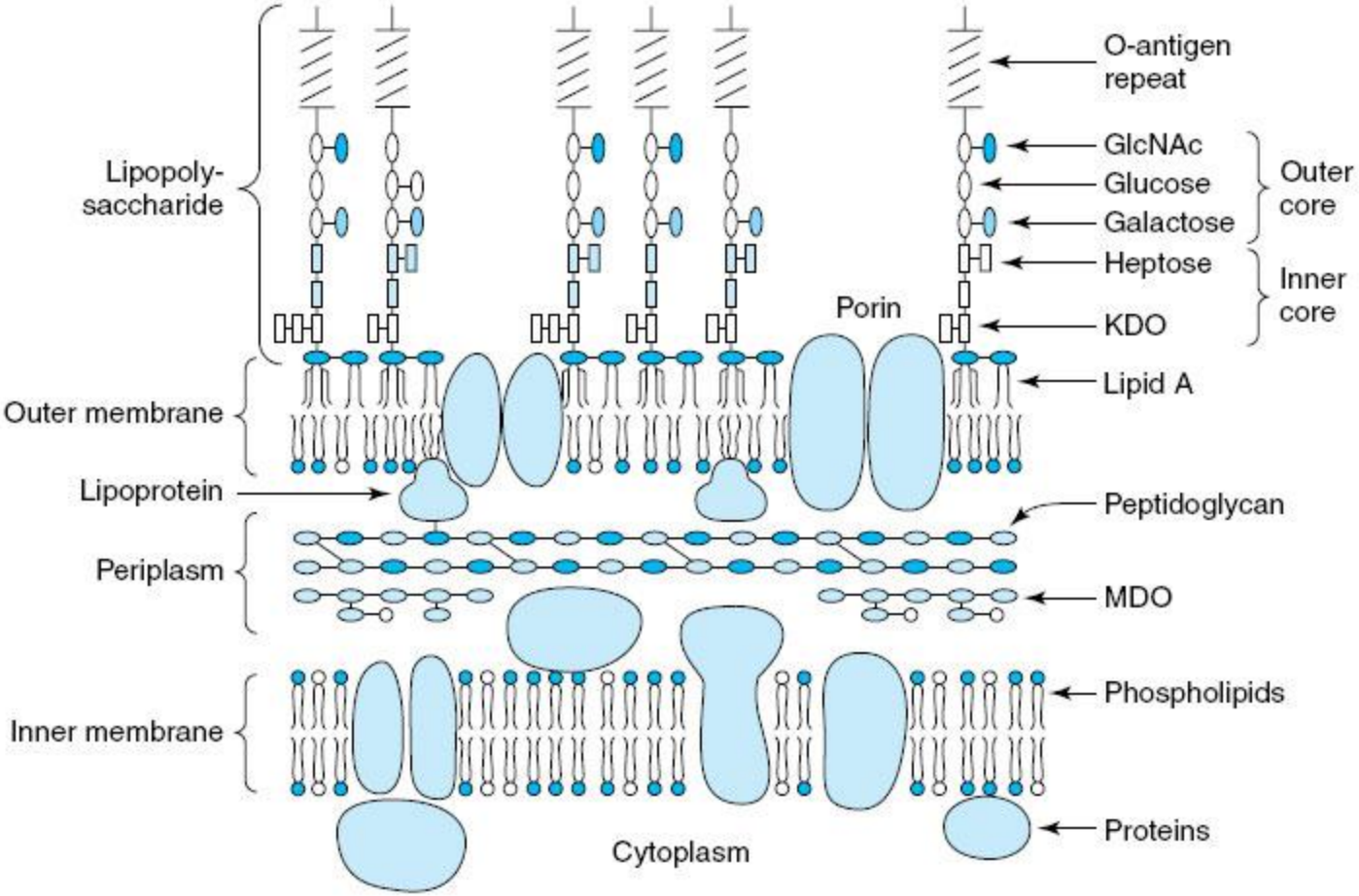
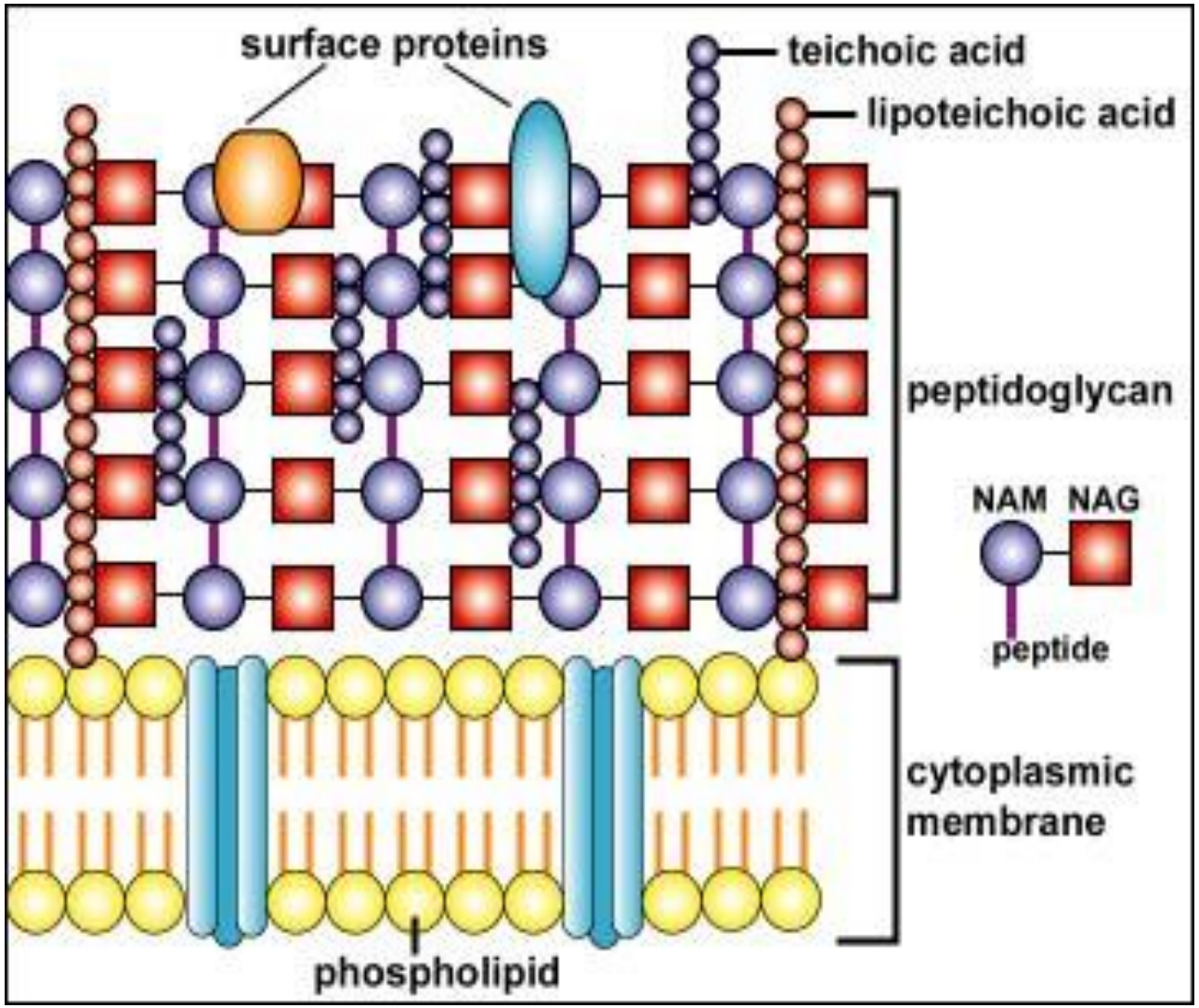


Figure 2–21. Molecular representation of the envelope of a gram-negative bacterium. Ovals and rectangles represent sugar residues, whereas circles depict the polar head groups of the glycerophospholipids (phosphatidylethanolamine and phosphatidylglycerol). (MDO, membrane-derived oligosaccharides.) The core region shown is that of *E coli* K-12, a strain that does not normally contain an O-antigen repeat unless transformed with an appropriate plasmid. (Reproduced, with permission, from Raetz CRH: Bacterial endotoxins: Extraordinary lipids that activate eucaryotic signal transduction. J Bacteriol 1993;175:5745.)

Outer Membrane

- Gram negative bacteria:
  - major permeability barrier.
  - space between inner and outer membrane.
    - periplasmic space.
      - ❖store degradative enzymes.
- Gram positive bacteria :
  - no periplasmic space.

Gram-Positive Cell Wall



Gram Positive Cell Envelope

Teichoic acid:

- **polymer**
- **phosphorus**
- **ribitol or glycerol backbone**
-

- **Teichuronic acid:**
  - **polymer**
  - **no phosphorus**
  - **glucuronic acid backbone**

Gram Positive Cell Envelope

Teichoic and teichuronic acids

- Functions:

- **Metal ion uptake.**
- **Direct autolytic enzymes.**
  - **holes punched in cell wall**
  - **allows insertion cell wall (synthesis)**

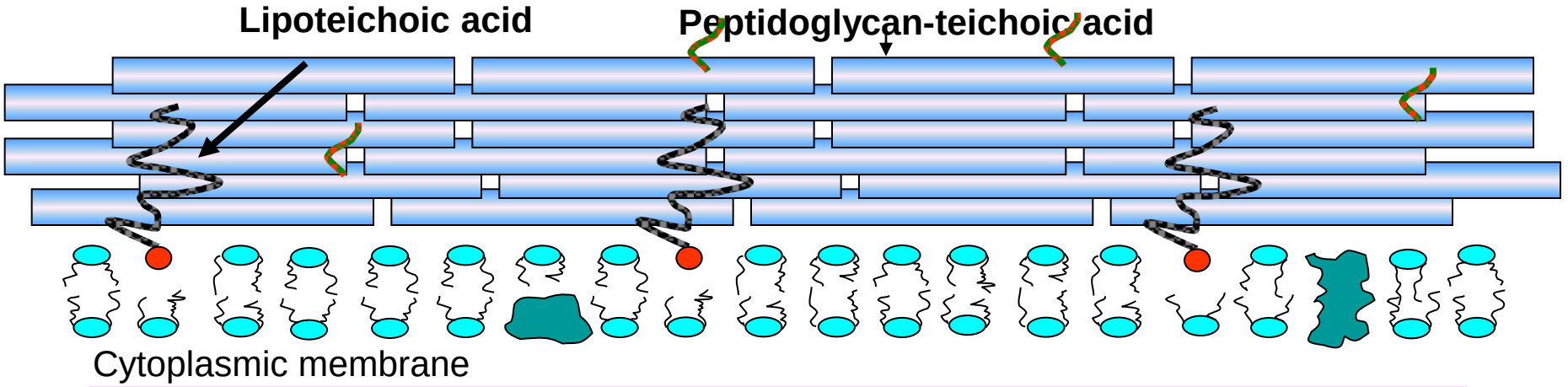
Gram Positive Cell Envelope

Lipoteichoic acids

- Functions:

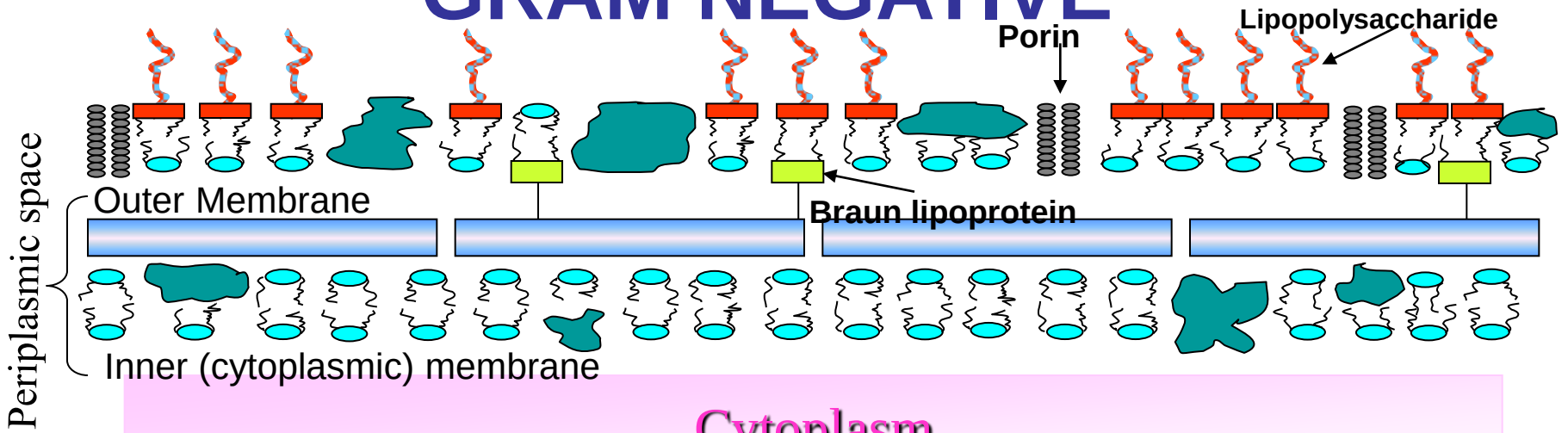
- **Cell membrane.**
- **Autolysins kept from cell wall**

GRAM POSITIVE



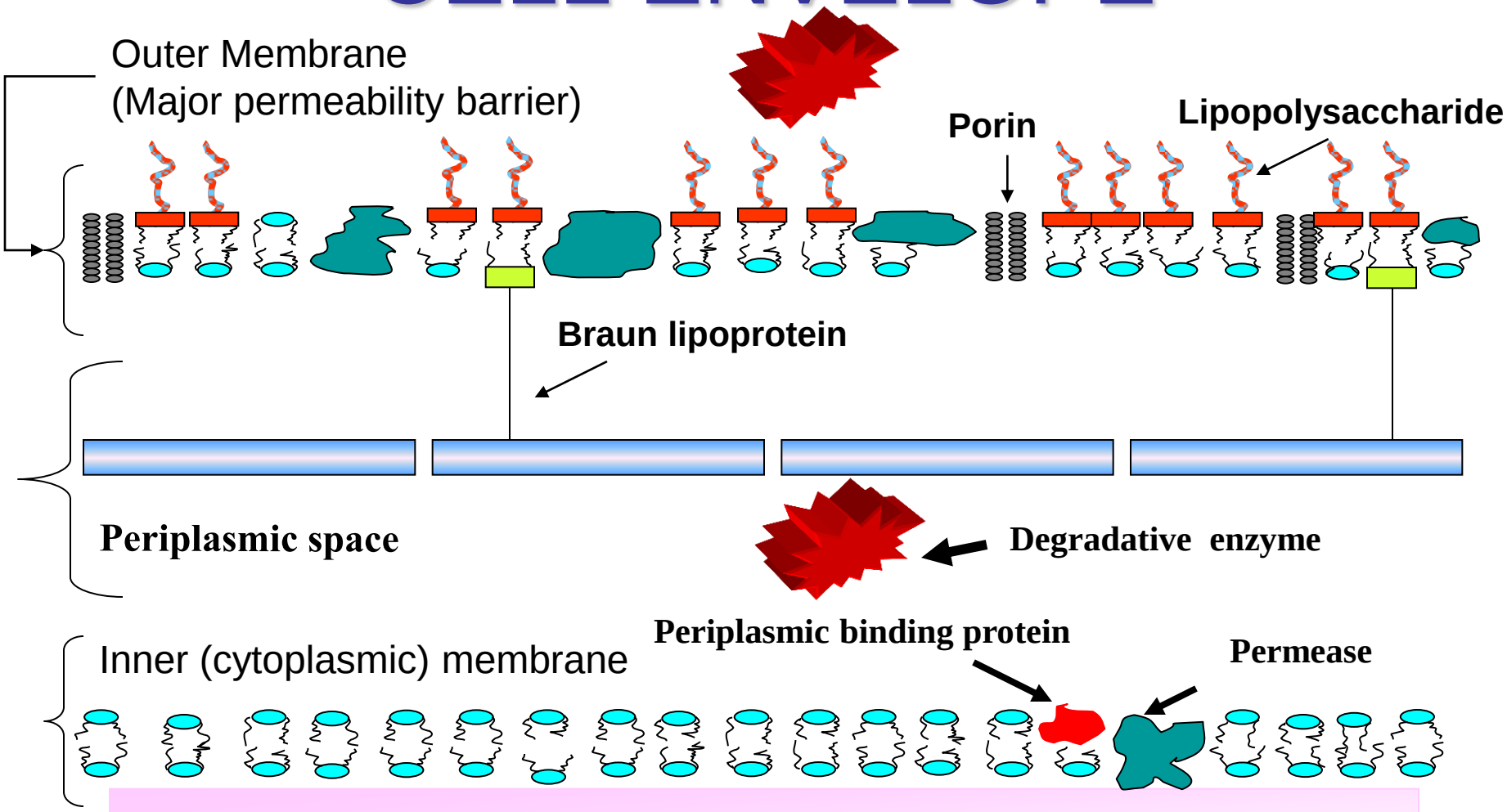
Cytoplasm

GRAM NEGATIVE

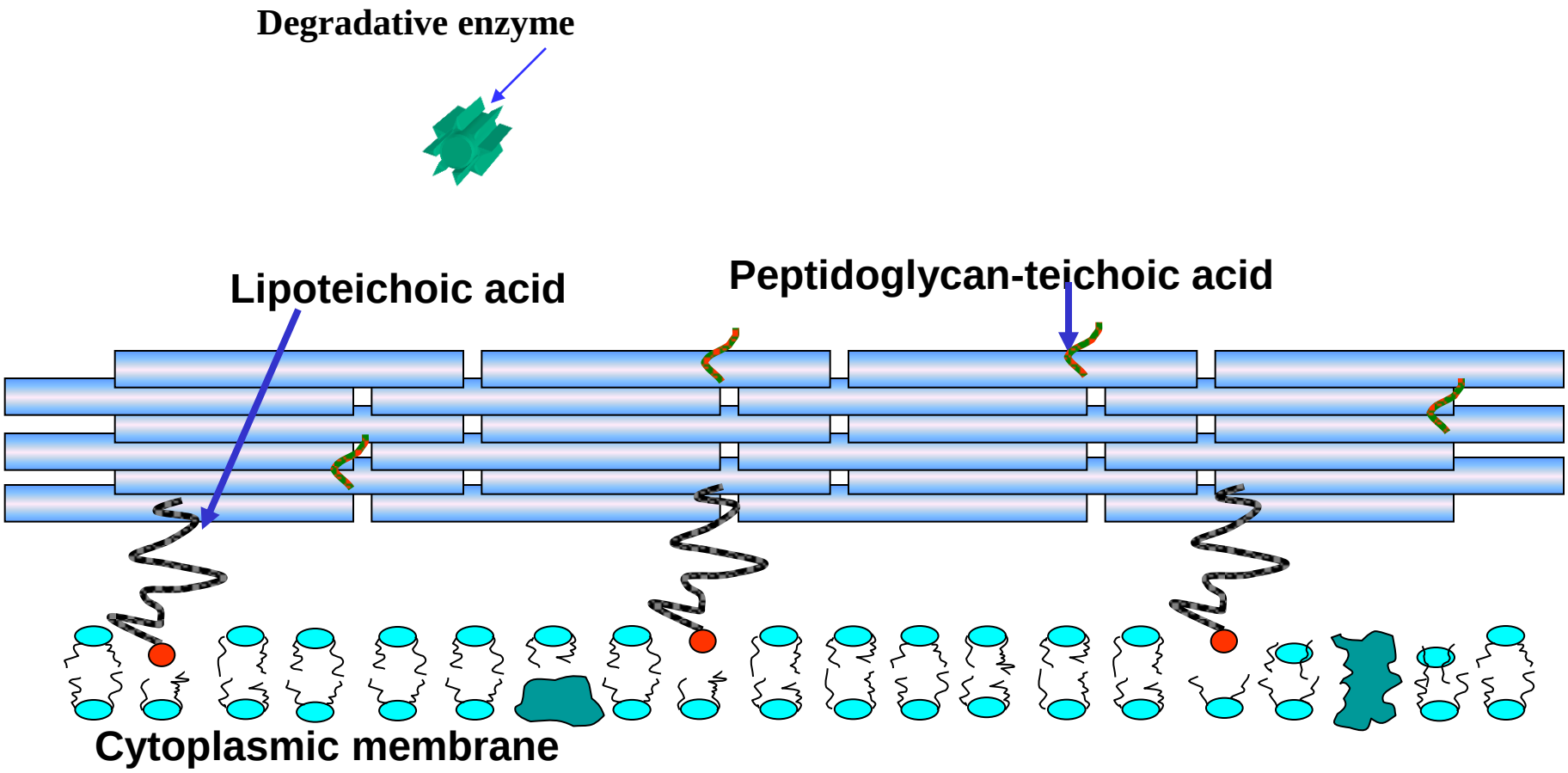


Cytoplasm

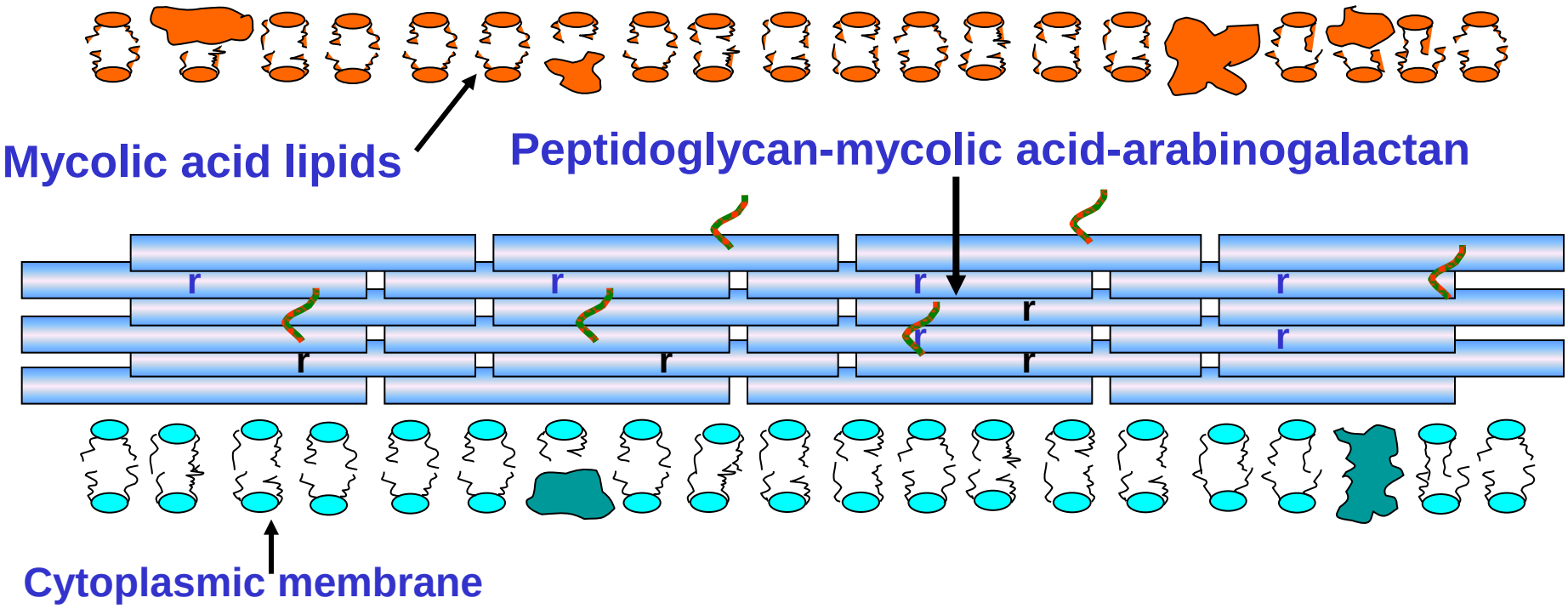
GRAM NEGATIVE CELL ENVELOPE



GRAM POSITIVE CELL ENVELOPE

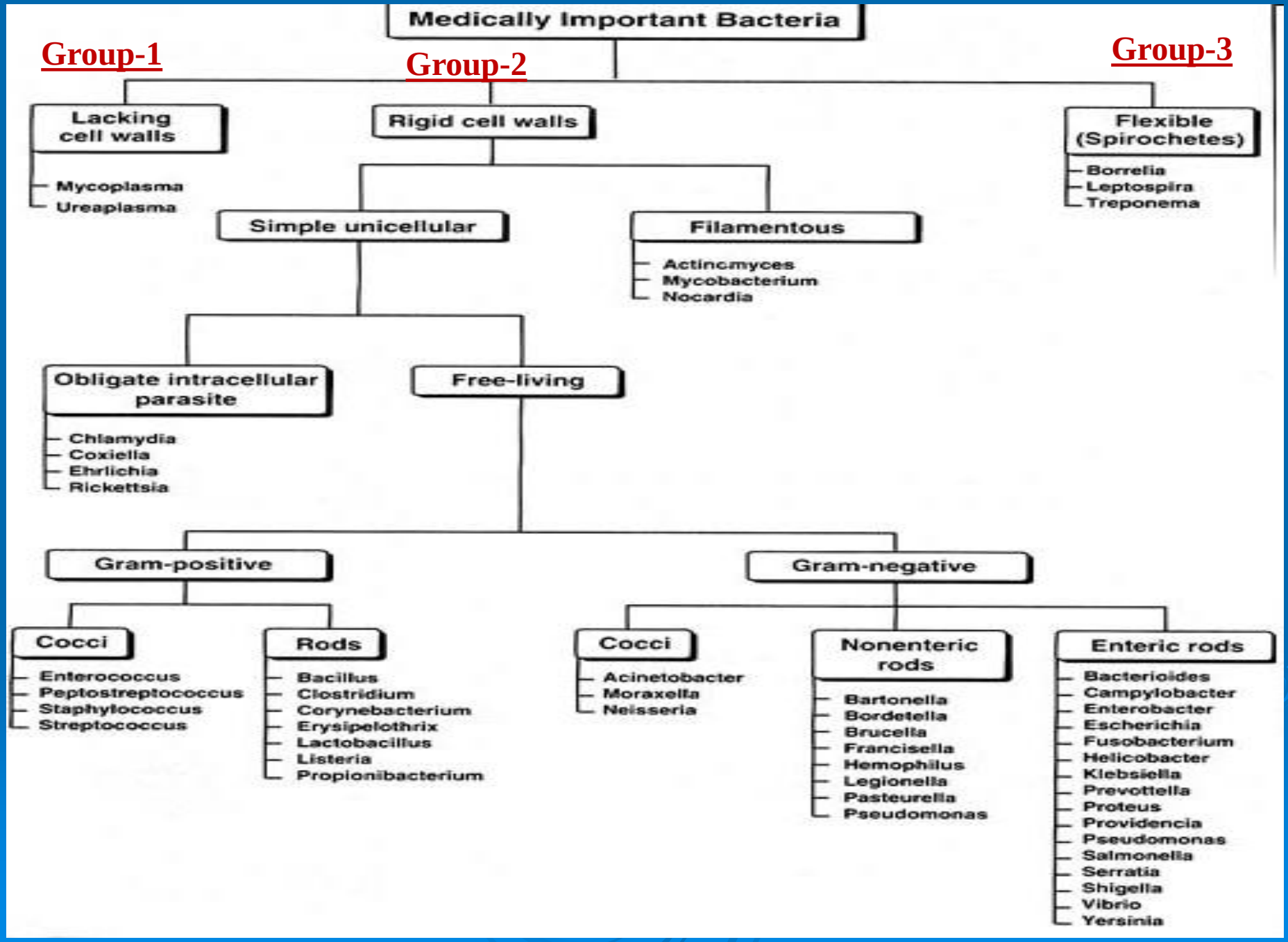


Acid Fast Cell Envelope



Cytoplasm

Medically important Bacteria can be classified according to cell wall into 3 groups:


Medically Important Bacteria
Group-1
Group-2
Group-3
Lacking cell walls
Mycoplasma
Ureaplasma
Rigid cell walls
Flexible (Spirochetes)
Borrelia
Leptospira
Treponema
Simple unicellular
Filamentous
Actinomyces
Mycobacterium
Nocardia
Obligate intracellular parasite
Chlamydia
Coxiella
Ehrlichia
Rickettsia
Free-living
Gram-positive
Gram-negative
Cocci
Enterococcus
Peptostreptococcus
Staphylococcus
Streptococcus
Rods
Bacillus
Clostridium
Corynebacterium
Erysipelothrix
Lactobacillus
Listeria
Propionibacterium
Cocci
Acinetobacter
Moraxella
Neisseria
Nonenteric rods
Bartonella
Bordetella
Brucella
Francisella
Hemophilus
Legionella
Pasteurella
Pseudomonas
Enteric rods
Bacterioides
Campylobacter
Enterobacter
Escherichia
Fusobacterium
Helicobacter
Klebsiella
Prevotella
Proteus
Providencia
Pseudomonas
Salmonella
Serratia
Shigella
Vibrio
Yersinia

Bacterial Stains

Stain

1) Gram Stain.
2) Acid-fast stain.
3) Stains for special structures.

Differential Stains

- React differently with different types of bacteria.

- The 2 Most Common staining methods:
  1) **Gram Stain.**
  2) **Acid-Fast Stain.**

1- Gram Stain

- 1884 Hans Christian Gram.
- Most important stain used in Bacteriology.

- Divides all Bacteria into 2 groups:
  - **Gram (+)**
  - **Gram (-)**

The Cell Envelope

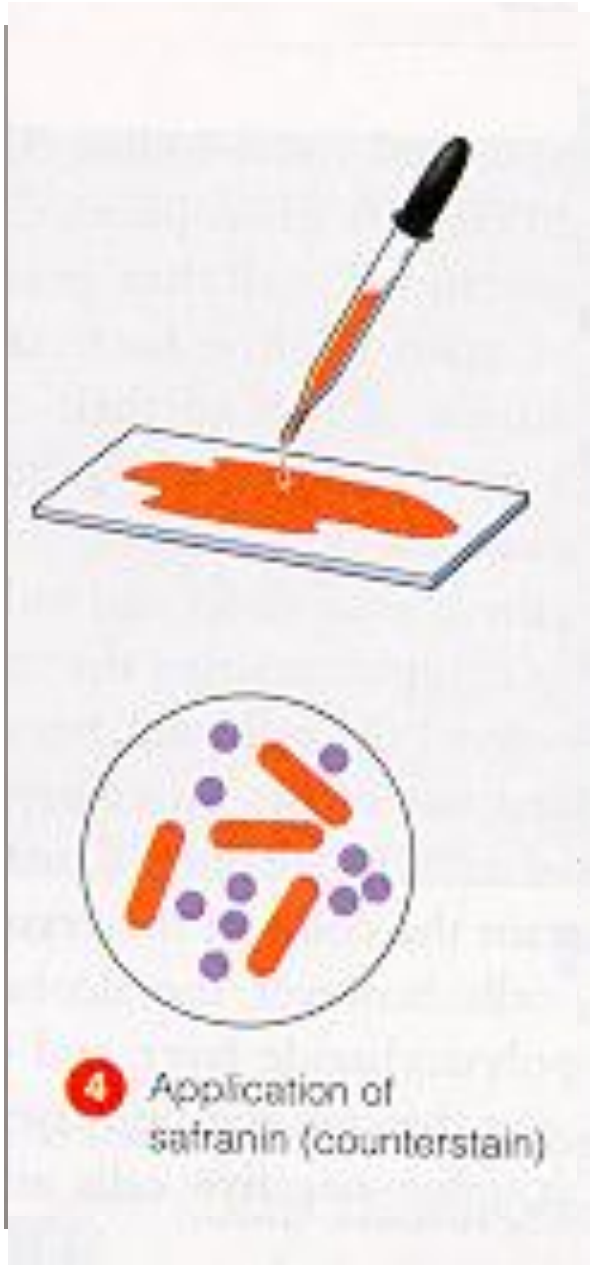
Gram Stain

1. **Crystal violet**

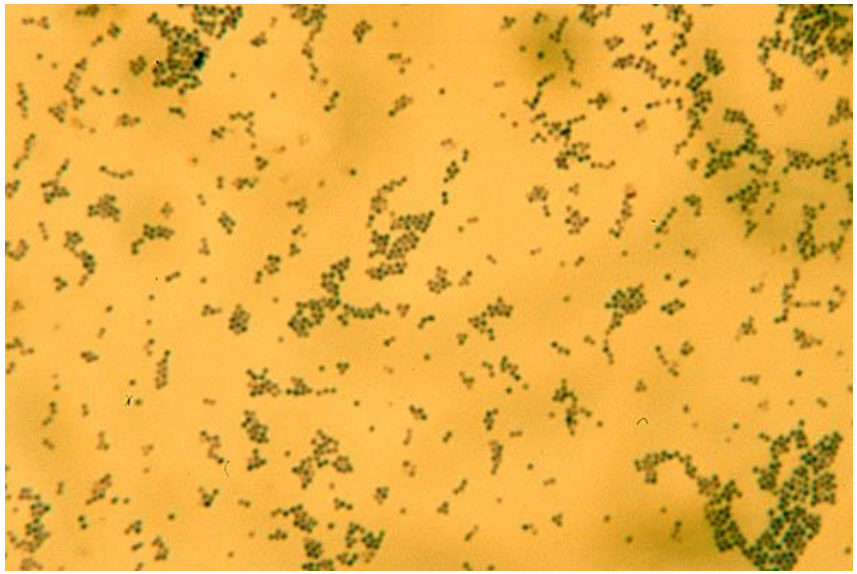
2. Grams Iodine (mordant)

3. Alcohol

4. **Safranin** (Counterstain)

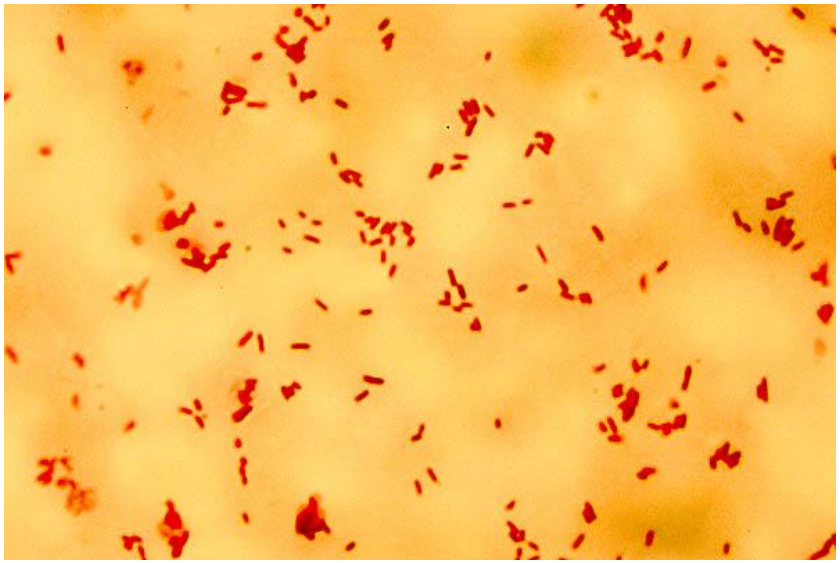


Gram Stain



Gram positive batceria

Staphylococcus



Gram negative bacteria

E. coli

Results

- Gram (+) Purple
- Gram (-) Red
- Difference - due to structure of cell wall
  - Gram (+) Thick cell wall
  - Gram (-) Thin cell wall

Gram stain

Crystal violet

Iodine

100% ethanol

Safranin

Step	Gram-positive organisms	Gram-negative organisms
1. Unstained	Clear	Clear
2. Crystal violet	Violet	Violet
3. Iodine	Violet	Violet
4. Decolorization (alcohol-acetone)	Violet	Clear
5. Safranin	Purple	Red

THANK YOU FOR YOUR ATTENTION!